ANATOMY, PHYSIOLOGY AND HYGIENE

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PREFACE TO REVISED EDITION.

THE call for a new edition of the "Anatomy, Physiology, and Hygiene" has afforded opportunity for a thorough revision of the text, and for the addition of thirty-three new illustrations and other important material.

Scientists and experienced teachers have been freely consulted, and the book as revised represents the results of important modern research in the subjects treated.

Great care has been exercised to insure accuracy of statement. The laws of the various States governing the presentation of the effects of alcohol and narcotics have been complied with.

Attention is directed to the prominence given to hygiene. The study of human anatomy and physiology is of little real value unless it leads to practical suggestions for the preservation of health.

If the pupil is not obliged to memorize the contents of the book in detail, but merely to grasp the salient points of the text, and carefully to read the footnotes and appendix in connection with it, he will not find it difficult to acquire knowledge which will be to him both a pleasure and a gain.

The services of Professor Atwater, Dr. T. D. Crothers, Dr. Eliza Mosher, Dr. E. H. Bartley, Dr. T. R. French, Dr. A. Mathewson, Dr. R. L. Dickinson, Dr. J. Scott Wood, Dr. J. C. Shaw, and others, in the revision of various portions of the manuscript or in other ways, are gratefully acknowledged.

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BROOKLYN, May, 1900.

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ANATOMY, PHYSIOLOGY, AND HYGIENE.

CHAPTER I.

THE HUMAN BODY.—GENERAL FACTS.

1. Scope of Study.—The study now to be pursued is primarily that of *Health*. It includes a consideration: 1, of *Human Anatomy*,[1] or a description of the form, structure, and location of the various parts of the human body; 2, of *Human Physiology*, which treats of the uses or *functions* of these parts; 3, of *Hygiene*, which treats

[1] The word *Anatomy* is derived from the Greek ἀνατομή, and signifies the act of cutting up, or dissection. Anatomical knowledge has been obtained by the dissection of bodies of the animal kingdom. The study of the general appearance and mutual relations of the bones, muscles, nerves, blood-vessels, and other parts is sometimes called "general" or "gross anatomy," to distinguish it from the study, by means of the microscope, of "minute anatomy," *i.e.* Histology.

The word *Physiology* is derived from the Greek φυσιολόγια, and signifies, literally, talk about Nature. It is now confined to a description of "the phenomena, the aggregate of which constitutes life." Physiological knowledge has been obtained by closely observing the actions of the various parts of living bodies in a state of health, and by operations upon living animals.

The word *Hygiene*, from the Greek ὑγίεια, "health," refers particularly to the health of man, both individually and in relation to the community. The application of health laws to individuals is known as "individual hygiene," and to communities as "public hygiene," "sanitation," or "preventive medicine."

of the preservation and improvement of the health of individuals and communities.

2. General Arrangement of the Human Body. — The human body is capable of more varied work than that of any other animal, and has therefore a more complicated structure. The head, neck, trunk, and limbs are composed of many parts, differing from each other in structure and in the specific work that they do, but all working together to maintain the life and energy of the body. Each of these parts is composed of structural elements called *cells*.[1] Cells united or interwoven in various ways form *tissues*. Tissues variously combined form *organs*, which have specific duties to perform. For example, the heart is an organ of circulation, a muscle is an organ of motion.

The body has been likened to a house; its organs, to the floors, doors, windows, and walls; its tissues, to the stone, wood, glass, mortar, and other building materials. It has also been likened to a machine. But it differs from these in many ways, chiefly in the possession of *life* and the association with its tissues of *fluids*, which afford moisture, nourishment, and lubrication, and carry from the body waste material, which, if retained, would prove poisonous. Among such fluids are the tears, blood, perspiration, and fluids in joints and other closed cavities.

3. Cells. — In all the higher forms of life, whether of plants or of animals, every part of the body is composed principally of *cells*.[2] These are minute structures, visible

[1] From the Latin *cella*, a closet or storeroom.

[2] "Each cell may be likened to a soldier, an organ to a brigade, the nervous system to headquarters and field telegraph, the digestive and circulatory systems to the commissary department of an army."

only by means of the microscope, vast in number and of great variety of form and structure; but they all conform to a characteristic type, and are held together by a delicate connecting material. Some of these cells are round, as in the blood; some flat and thin, as in the outer layer of the skin; some elongated, like the fibres in the muscles. Still others, which line portions of various channels like the windpipe, have hair-like threads, known as *ciliae*,[1] projecting from one end.

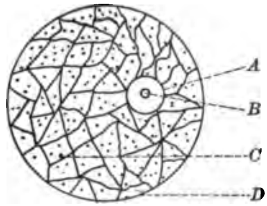

Fig. 1.

Diagram of a Cell.

A. Nucleus.
B. Nucleolus.
C. Protoplasm or cell body.
D. Cell wall, so called.

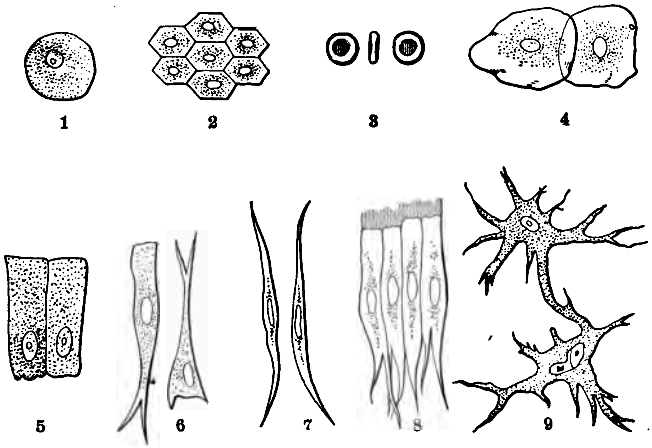

Fig. 2.

Various Forms of Cells.

1. Spheroidal.
2. Polyhedral.
3. Blood cells.
4. Scaly.
5. Columnar.
6. Caudate.
7. Fusiform (fibres).
8. Ciliated.
9. Stellate.

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[1] From the Latin, meaning "eyelashes."

Cells are masses of *protoplasm*[1] containing a *nucleus*,[2] and this sometimes contains a *nucleolus*.[3]

"Protoplasm is generally considered to be a viscid, translucent, granular substance, often forming a network or sponge-like structure extending through the cell body. The cell generally contains also other substances, such as food granules, pigment bodies, drops of oil and water, and excretory matters, or material to be thrown out. Protoplasm, deprived of its nucleus, may live for a time, and be able to move, but it has lost the power of taking into itself food for its growth and repair. The nucleus is for this reason, among others, considered as the controlling centre of cell activity, and hence a primary factor in the growth, development, and transmission of specific qualities from cell to cell, and so from one generation to another."

4. Cell Life. — The various functions of the body, both in health and disease, are but the outward expressions of cell activity. "*The cell is not only a unit of structure, but also a unit of function.*"[4] The lowest forms of life, as the *amoeba*, consist of a single cell, which does all the work of the body; hence they are spoken of as unicellular.

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[1] From the Greek πρῶτος, "first," πλάσμα, "material." It has also been called *bioplasm*, *i.e.* "life material."

[2] Latin, *nucleus*, "kernel."

[3] "The living cell is not, as the word implies, a hollow chamber, surrounded by solid walls. . . . Whenever cells are said to have walls, probably there is only a condensation of the outer layers of protoplasm." — PROF. E. B. WILSON, PH.D., *The Cell, in Development and Inheritance.*

[4] "It is the cell to which the consideration of every bodily function, sooner or later, drives us. In the muscle cell lies the riddle of the heart-beat, or of muscular contraction; in the gland cell are the causes of secretion; in the epithelial cell, in the white blood cell, lies the problem of the absorption of food; and the secrets of the mind are slumbering in the ganglion cell." — WILSON.

In the hydra, the common fresh-water polyp of our ponds and marshes, there are a number of cells and a division of work among them, a "specialization of function." Higher still, where structure and function are intricate, cells are grouped together into "colonies," or aggregations constituting organs.

5. **The Division of Labor.** — Multi-cellular organisms, by dividing the labor, cause more and better work to be done in the maintenance of life, just as in a well-organized community one set of persons acts as policemen, another distributes the mail, another cleans the street, and another teaches in the schools, — all working together for the common good. Over this community is placed one or more persons, whose business it is to see that harmony prevails and that the public welfare is upheld; for what is best for the community as a whole is best for the individuals that compose the community.

A similar condition exists in the body with regard to physiological labor. Every cell and organ has a special work to do, and is constructed with reference to that work, but each one relies on the others for mutual support. And what is best for the body as a whole is best for each part of it. The red blood cells carry food and oxygen to all the tissues; the muscle cells cause motion; the gland cells *secrete*, or accumulate, material to moisten or lubricate; other cells *excrete*, or get rid of, waste material; and over all preside the brain cells, to regulate and harmonize functions, and to receive messages from both inside and outside the body. This specialization of function is called *differentiation.*

6. **Phases of Life.** — The human body, like that of the lower animals, begins in a microscopic cell and passes

through the various stages of birth, growth, development, decline, and death. This is also true, to a large extent, of each part of the body and of its structural elements. When cells have completed their allotted work they degenerate and die, and are cast out of the body by the skin, lungs, bowels, or kidneys. This is local death, as distinguished from death of the entire body, or general death. The entire life of cells is probably measured by days. Hence there is constant death of individual cells in the body, as well as constant birth. Continued activity of parts of the body is accomplished by cell reproduction or proliferation. Cells produce other cells

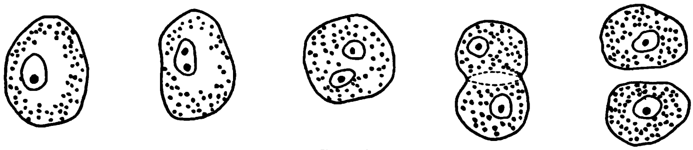

Fig. 3.

Cell Division — Various Stages.

similar to themselves, mainly by what is known as *cell division*, — *i.e.* each cell divides into two, which are like the parent cell, and these two into four, and so on. Indefinite multiplication of cells and consequent undue enlargement of parts of the body is prevented by some of the cells failing to divide, either as the result of injury or disease.

So intimately are the internal parts of the body related to one another, that if one weakens or dies, others are almost sure to do likewise. This chain of vital connections constitutes the so-called "circle of life."

Man and other living organisms closely resemble each other in their birth, decline, and death; but the capacity

which man possesses for development, especially of the brain, is the marked distinction between human beings and the lower animals.

7. The Work of Life. — The pervading influence or inherent power that we call *life* (about which we know little except as to its effects) enables the living body to assert its needs through its various parts. Thus, if it needs nourishment, it calls for food through the stomach by means of the sensation of hunger; when it needs air, the lungs make known a desire for breathing. If the strength of this pervading influence is diminished, impaired health results; if it ceases, death follows.

The way in which the specific duty or function of an organ is performed is known as a *process;* for example, the respiratory process, the digestive process. All of the processes carried on in the living body are essentially vital processes, since they cannot be performed except during life. But they are frequently grouped as follows: 1. *Chemical processes*, such as the transformation of material into carbon dioxide, water, etc. 2. *Mechanical processes*, such as the grinding of food in the mouth and the motion of the muscles of the stomach in the digestion of food. 3. *Vital processes*, or those often considered most necessary to the maintenance of life, such as breathing, digestion, and the circulation of blood.

Living bodies are constantly forming complex substances from simpler ones, thus storing energy and building up living material. They are also constantly taking oxygen from the food and the atmosphere, and transforming complex substances into simpler compounds, of which the simplest and final ones are water and carbon dioxide, which pass out of the body as *excretions*. This breaking down of

complex substances is called *oxidation*. It sets free a certain amount of energy.

The combined effect of the different kinds of work performed by the cells is to maintain the *balance* of the body, *i.e.* the proper relation between repair and waste, between income and outgo, which constitutes health or wholeness. The various changes necessary to accomplish this are grouped together as *metabolism*.

8. Properties of Living Matter.—Living things have the power of *reproduction*, by which the species is continued. They have the power of *assimilation*, *i.e.* of appropriating from their food the materials needed for the sustenance and building up of their various portions. The cells of our bodies take from the nourishing blood the particles they individually need. For example, muscle cells assimilate material for muscle; bone cells, material for bone, and so on. With assimilation comes the power to grow or increase in size, to develop or increase in capability, and then to reproduce. Living things are also *excitable*, *i.e.* they—each in its own peculiar manner—respond to external impressions, such as cold, heat, a blow, or nervous force. These excitants are spoken of as *stimuli*. Some cells when stimulated secrete, others excrete, while in others the protoplasm alters its form. Certain cells in our bodies, like some of the one-cell forms of animal life, have the power of moving from place to place by the alternate protrusion and retraction of various portions of their protoplasm. Movements of this sort are called amoeboid movements, since they resemble those of the *amoeba*. They enable the lymph cells and the white blood cells to pass, through the thin walls of the vessels in which they float, into surrounding tissues.

Such migration is known as *diapedesis*,[1] and the cells engaged in it are emigrant or migratory cells. Disease sometimes spreads from one tissue to another by means of these cells.

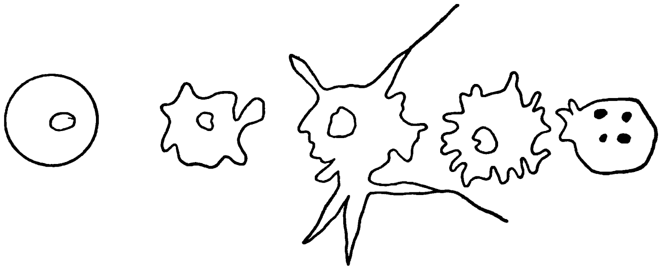

Fig. 4.
Amoeboid Movements.

Another form of motion inherent in certain cells is the *ciliary*, the waving to and fro by means of ciliae. Muscular motion, through the alternate contraction and relaxation of muscular fibres, is also a property possessed by many living things.

9. **Membranes.** — Fibrous, sheet-like tissues, which cover certain organs and connect certain parts of the body, are called *membranes*. Some membranes, placed as partitions between two fluids or gases, permit them to mingle. This process is known as *osmosis*. The passage of the fluid or gas inward is *endosmosis;* outward, *exosmosis*. The absorption of a fluid by a cell or membrane is *imbibition*. Osmosis is illustrated in the changes which occur in the breathed air during respiration · imbibition, in the transformation of food into blood.

[1] Greek, διά, "through," πηδᾶν, "to leap."

10. The Tissues. — The tissues of the body may be classified as *supporting tissues* and *active tissues*. The former include bone and cartilage, which provide a strong framework for the body. They also include connective tissue, which in some parts of the body is delicate and elastic, and in others is fibrous and strong. In the meshes of the connective tissue are fat, lymph, and other materials used for the ordinary nutrition of the body, or stored up for emergencies.

Connective tissue,[1] as the name implies, connects and holds in place the various organs of the body. It so closely covers, or is so interwoven with, all the textures of the body that, if all other tissues could be removed and the connective only be left in normal position, we should have an almost exact model of the various organs in the body, even to their minutest structure. What connective tissue is will be best understood if we compare it with the inside of an orange after the juice has been sucked out. As motion is necessary to life, it will be appreciated how thickening of the connective tissue, which sometimes results from disease, will impair the motion and consequent health of parts. One of the evil effects of alcoholic drinks is a thickening of the connective tissue, especially in the liver and brain.

The *active tissues* of the body, such as muscles and nerves, are those that perform its activities. Among them is a group known as the *epithelial*,[2] comprising mainly the outer skin and the lining of cavities and canals, and intimately concerned in secretion and excretion.

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[1] The various kinds of connective tissue are the areolar, fibrous, elastic, adipose, retiform, and lymphoid. For one form, see Fig. 34.

[2] Classified as simple, pavement, ciliated, and lining.

11. Value of Health. — Health enables one to do the best work that he is capable of. It also "brings so many charms and such great blessings, it is indeed a pity so few possess it. Health means a clear skin, a bright eye, a firm step, erect carriage, graceful movements, great powers of endurance, and the cheerful temper that waits on good digestion."

Disease not only causes misery, but is expensive, as it interferes with the earning capacity of the person afflicted, and necessarily makes an increase in expenditure. Health boards find their most energetic opponents among the badly housed, the poorly fed, and those ignorant of hygiene (*a*).[1] "Public health is public wealth." National, state, city, and town boards of health and other sanitary organizations should be heartily supported, as their object is to prevent the spread of disease and to lessen the rate of mortality. Much good has been accomplished by these associations in the past, much more may be done in the future. Sanitation has lessened the virulence or stopped the ravages of epidemics of typhoid fever, smallpox, and diphtheria, has improved the quarters on shipboard devoted to immigrants, and thus has prevented much sickness and many deaths. It has cut down the death rate of armies and public institutions over one-half. Experience shows that usually, where sanitation is not or can not be enforced, more soldiers die in wars from sickness than from injuries inflicted by the enemy (*b*). It will be a matter of interest to notice the increase in healthfulness in Cuba, Porto Rico, and the Philippine Islands, when civic and personal cleanliness, the prompt removal of sewage and other waste material, the isolation

[1] (*a*), (*b*), etc., in the text refer to the Appendix.

and proper care of cases of contagious and infectious diseases, and the prevention of overcrowding in dwellings become the rule, not the exception.

12. Animal Heat. — In order to perform efficiently its various processes, the body must have a pervading temperature, just as ordinary machinery requires a certain amount of warmth to make it work well. This temperature of the body is known as the *vital* or *animal heat.* Animals having a temperature generally higher than that of the surrounding atmosphere, as in man, quadrupeds, and birds, are known as warm-blooded animals; while fishes and reptiles are called cold-blooded animals, their temperature varying but little from that of the air or water in which they live. The temperature of man in health is 98½° to 99° F. When it is higher than this point, especially if above 102°, as in fever, the condition indicates that certain tissues are being consumed by too rapid functional activity. A temperature of 105° generally marks a severe attack of some disease, and a temperature of 110° to 112° is very quickly fatal, unless it yields to medical treatment. In starvation and great prostration the temperature is usually below the normal point; if below 92°, the probability of recovery is small. The principal danger in high and low temperatures is from an accumulation of poisonous products. The "balance" of the body is lost.[1]

Though the average normal temperature, as ascertained by the thermometer, is about 98½° F., the general tem-

[1] Animal temperature is usually ascertained by means of a thermometer made for that purpose, known as a "medical," or "clinical," thermometer. When in use, the bulb of the instrument is generally placed in the armpit or under the tongue, the lips being closed to exclude air.

perature of the interior of the body is about 100°, the temperature of different parts of the body varying somewhat. In the skin and lungs, by reason of the contact of air and the vaporization of water, the blood is cooled a little, and the animal temperature is slightly diminished. On the other hand, the temperature is raised in the muscles and glandular organs, especially during their functional activity, and, above all, in the liver. The lowest body temperature in a day is usually early in the morning, from 2 to 6 o'clock; the highest, from 5 to 8 P.M. Young children have the highest normal temperature, and old people the lowest. The ordinary tests of life are the power to assimilate food and air, the power to move or to be aroused, and the possession of animal heat. When the heart ceases to beat and breathing stops and heat leaves the body, a person is said to be dead. Instances are on record where life has been restored by the application of heat to the body, both externally and internally, by the use of stimulants, and by arousing the circulation and the action of the lungs by means of electricity and by the practice of artificial respiration.[1]

13. **Sources and Loss of Heat.** — Some heat enters the body with food, some by radiation from the sun and from fires. It is also produced in the body by the oxidation of its substances, by the transformation of food, by muscular action, and by other manifestations of animal life; in short, by cell activity. The production of heat in living organisms is in proportion to the activity of their internal changes. When produced, it is carried through the body by the blood, and is also distributed by direct conduction

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[1] See Emergencies, p. 384, as to artificial respiration.

from one part to another near by. It is controlled by a nervous mechanism in the brain.

Heat escapes from the body: 1, from the surface of the skin, by radiation, conduction, and convection; 2, as latent heat in the watery vapor escaping through the skin and lungs; 3, through the material excreted from the kidneys and bowels.

14. Chemical Composition of the Body. — The chemical constituents of the body are only nineteen[1] in number, and are, for the most part, found in the tissues in various combinations. These may be divided into *inorganic* (*i.e.* not being or having been living organisms) and *organic*.

Inorganic Constituents. The most important inorganic constituents of the body are *water* and *common salt*, these being found in all its tissues and fluids. Phosphate and carbonate of lime (calcium phosphate and calcium carbonate) form a large portion of the bones and teeth; while free hydrochloric acid (muriatic acid) is found in the gastric juice, — the digestive secretion of the stomach.

Organic Constituents. There are three principal classes of organic constituents, viz. *proteids*[2] (or albuminous substances), *carbohydrates*, and *fats*.

Proteids are complex compounds of nitrogen, carbon, hydrogen, and oxygen, with sometimes a small percentage of sulphur, phosphorus, and iron. They are the most important organic chemical compounds, as there is reason to believe they form the principal basis of living proto-

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[1] Carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, chlorine, iodine, fluorine, silicon, sodium, potassium, calcium, magnesium, lithium, iron, and usually traces of manganese, copper, and lead.

[2] From the fact that proteids are the only substances that contain nitrogen, they are sometimes called nitrogenous substances.

plasm in all its forms. They are not found in the hair, nails, or teeth. Sometimes they are called *albuminous* substances, because they resemble the white of eggs, which is largely albumin dissolved in water. The most important proteids in the body are *serum albumin* in the blood; *fibrin*, which forms in blood when it clots; *myosin* in muscles, which after death coagulates, causing the stiffening of the body known as "rigor mortis"; and *casein* in milk, which forms the principal ingredient of cheese.

Carbohydrates, or saccharids, consist of carbon, hydrogen, and oxygen (the last two in proportion necessary to form water), and belong to the same class of substances as sugar and starch. The principal carbohydrates in the body are *glycogen* (or so-called animal starch), stored up in the liver and muscles, *glucose* or *grape sugar*, and *lactose* or *milk sugar*.

Fats, also, consist of carbon, hydrogen, and oxygen. The principal fats in the body (differing from each other mainly in their consistency) are *palmitin*, *stearin*, and *olein*.

15. Bacteria. — Certain parasitic unicellular micro-organisms, known as *microbes*,[1] but more commonly called *bacteria*,[2] frequently enter the body with food or air. They differ much as to mobility and shape. Some of them (*micrococci*) are spheroidal, some (*bacilli*) are rod-shaped, and others (*spirilli*) spiral-shaped. They propagate by cell division, and very rapidly, if they find agreeable food and sufficient heat and moisture. It is

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[1] Greek, μικρός, "little," βίος, "life," — minute living bodies.

[2] Greek, βακτήριον (singular), "a staff," — a very common form of micro-organism. Some bacteria are less than $\frac{1}{25000}$ of an inch in size.

estimated that a single bacterium in suitable locality, if unhindered, will in one day increase to several millions. Most of the bacteria which enter the body are harmless, as they thrive only on dead material. Many of them are destroyed by the acid secretion of the stomach, unless that organ is diseased or very much disordered, or has its inner

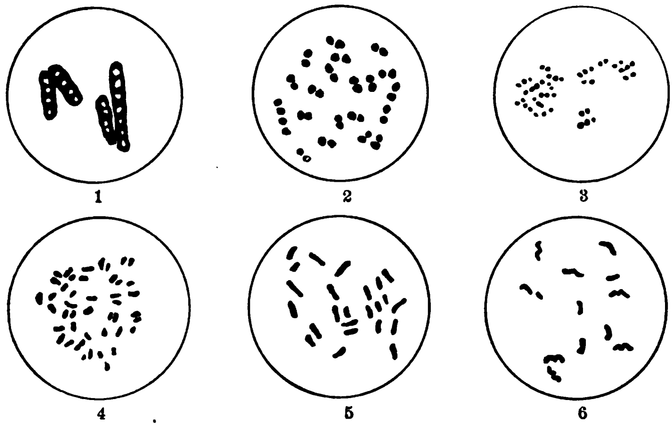

Fig. 5.—Various Bacteria, Much Enlarged.

1. Consumption bacilli.
2. Pneumonia micrococci.
3. Diphtheria bacilli.
4. Influenza bacilli.
5. Typhoid fever bacilli.
6. Cholera spirilli.

surface wounded. In health, certain white blood cells also have the property of destroying bacteria. Sometimes, however, bacteria enter the body through open wounds, or with the food, or in other ways, and hinder the work of tissue cells or destroy them, feeding upon their albuminous substances, and producing poisonous products known as *ptomaines*[1] and *toxins*.[2] These bacteria are

[1] Greek, πτῶμα, "a dead body." [2] Greek, τοξικόν, "arrow poison."

more active than the harmless varieties, and are known as *disease germs.*[1] Diphtheria, typhoid fever, cholera, erysipelas, consumption (tuberculosis), lockjaw, and the grippe are diseases caused and spread by disease germs, and so are called *communicable* or *infectious diseases.* The principal danger from these diseases is the contamination of the blood by the poisons developed through the activity of disease germs, and the consequent overpowering of the vital processes. If we do not allow ourselves to run down in health, if we keep ourselves and all about us clean, if we do not partake of food which contains ptomaines or poisonous bacteria, we shall be likely to escape the ravages of disease germs.

Some infectious diseases, such as cholera and yellow fever, derived from putrefactive sources, are known as "filth diseases." Flies sometimes carry germs of typhoid fever from one person to another. It is estimated that more than one-third of all the deaths that occur are from infectious and contagious diseases. The spread of such diseases may usually be prevented by proper sanitary precautions.

16. Contagious Diseases. — These are certain infectious diseases that are conveyed from one individual to another, and are believed to be bacterial in origin. Such diseases are measles, scarlet fever, mumps, whooping cough, and small-pox. Nurses in charge of cases of contagious and infectious diseases should keep themselves and their clothing clean, as well as the patient and the room, should have plenty of sleep and food, and should exercise daily in the open air.

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[1] Germs — seeds.

17. Immunity from Infectious Diseases. — Some infectious diseases, such as yellow fever or scarlet fever, are not likely to attack a person a second time, and one who has had any of these is said to be *immune*. During the Spanish-American war, a regiment of yellow fever immunes was sent to the city of Santiago, in Cuba, to do guard duty, as yellow fever was prevalent there, and it was thought best not to expose troops not immune to the danger of infection.

From a very early period, in India and China, the virus or infectious material of small-pox was injected into the blood of those who had come in contact with persons afflicted with that disease. This injection produced a modified small-pox, much less dangerous than the original disease. This operation is known as *inoculation*, and was introduced into Europe in 1717. Later, Dr. Edward Jenner, of London, noticed that cows were subject to an eruptive disease similar to small-pox. This was known as cow-pox, or kine-pox. Injecting into the human system some of the clear fluid (serum) from the pocks, or eruptive points, upon the cow, he succeeded in exempting from small-pox the persons treated, or in modifying the disease. But as the serum of cow-pox was not easily obtained, he used serum from a person inoculated with cow-pox, with good results. This is *vaccination*, and was first tried by Jenner in 1776. The modified disease produced is known as vaccinia, and will give immunity from small-pox for ten to twelve years, as a rule. Vaccination at present is mainly accomplished by means of "bovine lymph," or serum from healthy calves which have been vaccinated, rather than by the use of virus from the vaccinated spot on a human being.

In 1885, Louis Pasteur performed a series of inocula-

tions upon rabbits, using the diluted poison of rabies, or hydrophobia. As a result he obtained a material which, when introduced into the human system by inoculation, renders harmless the bite of a mad dog.

Good results have also been obtained by the inoculation of the attenuated or weakened virus of cholera, the plague, and other infectious diseases.

Within the last few years it has been shown that if the *toxins* of diphtheria are injected into the blood of a healthy horse, in small quantity and from time to time, for weeks or months, that the horse, notwithstanding the poison, remains well. It is believed that a new substance has thus been formed in its blood, to which the name *antitoxin* (*i.e.* opposed to poison) has been given; for if serum obtained by the coagulation of blood drawn from the horse is injected into a person having diphtheria, it tends to overcome the germs of the disease and cause a cure, rendering the person immune for a considerable time. This is the *antitoxin treatment of disease;* it has also been used satisfactorily in poisoning from snake bites.

18. Nature and Specific Effects of Alcohol.—*Alcohol* is justly responsible for many acute and chronic ailments, and for much of the misery, crime, and moral degradation that afflict mankind. The form in which it is commonly used is ethylic alcohol, or spirits of wine. This is a chemical combination of oxygen, carbon, and hydrogen, and is usually obtained by the action of a peculiar ferment (yeast) upon the saccharine substances in fruits, cereals, and other materials. Other varieties of alcohol (amylic, etc.) form "fusel oils," which are very poisonous oily liquids, sometimes found in the poorer and cheaper kinds of alcoholic liquors. They are more pronounced

in their immediate effects, especially upon the nervous system, than is ordinary alcohol. The liquors which contain them frequently produce a brutal frenzy, and a tendency to murder and other heinous crimes.

Ethylic, or ordinary, alcohol is never used by itself as a beverage, except by the most degraded of drunkards. Sometimes it is used deliberately as a poison.[1] Largely diluted with water, it is used at times by physicians as a medicine, in the place of *alcoholics*, or alcoholic liquors, which are mixtures of alcohol, water, and flavoring substances or extracts.

Pure alcohol is a colorless, limpid liquid, with a sharp, burning taste and an intense affinity for water. It is mainly used to dissolve resins, essential oils, and medicinal extracts, in the manufacture of perfumes, essences, and medicines. Applied to albuminous animal tissues, it abstracts water from them, and so hardens them and interferes with their pliability that they perform their functions with difficulty. The local action of commercial alcohol (a liquid consisting of from 53 to 94 per cent alcohol, and the remainder water) is similar to that of pure alcohol, but less severe.[2]

19. General Effects of Alcohol. — The effects of alcohol taken internally vary according to the quantity consumed, the degree of dilution, and the constitution of

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[1] There is no recognized legal definition of a poison, but Quain's *Dictionary of Medicine* defines it as "any substance which when introduced into the system, or applied externally, injures health or destroys life, irrespective of mechanical means or direct thermal changes."

[2] The practice of preserving anatomical and other specimens in alcohol has been largely discontinued, owing to the hardening and distorting effects of the alcohol upon the specimens.

the consumer.[1] In small quantities, the effects are temporary stimulation or excitation, followed by depression, when taken in quantities beyond what for each individual may be termed his physiological limit. The heart beats more rapidly, the flow of blood is increased; there is a temporary increase in animal heat and in mental activity.

In larger amounts, it produces *acute alcoholism*, *i.e.* drunkenness, or intoxication, and acts principally upon the nervous system, deadening sensibility, perverting the reason, inducing irregular muscular action, flushing the face, and interfering with speech. Thus used, it is a paralyzer and depressant. In still larger amounts, it is a *narcotic* poison,[2] producing stupor, coma, convulsions, and even death.

The habit of drinking, or the repeated use of alcohol, *i.e. chronic alcoholism*, has been shown, by investigations made within the last few years in Europe and this country, to affect the cellular protoplasm. Alcohol, so used, by producing inflammatory action, destroys the usefulness of many cells in the body, the most vulnerable being the nerve cells, or those having the most complex functions. It disturbs the relations between the normal income and outgo of the body, by substituting hardened (fibroid) material for the delicate protoplasm of cells. It delays oxidation, especially of fats, which accumulate in undue amount, particularly in the liver cells. This is especially true of the habitual use of ale, beer, and other malt liquors.

Professor Conn says:[3] "To state that alcohol in any quantity is safe is a woful misinterpretation. No one can

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[1] Some physiologists consider alcohol as always injurious, and hence designate it as a poison.

[2] Persons so poisoned are often spoken of as "dead drunk."

[3] *The Christian Advocate*, July 13, 1899.

yet state at what point the secondary injurious effects begin, and no one can state what is a small and what a large dose. Further than this, it is certain that as commonly used by the American people it is not used in quantities so small that its secondary abnormal effects are not produced. As commonly used by our people its action becomes abnormal, and there is thus considerable justification for the name of *poison* which is applied to it. Alcohol is not used as a food. It is used always for its influence upon the nervous system, and one of the well-known results is that, at least among Americans, the use of alcohol in small amounts is almost sure to pass speedily into its use in larger quantities. When used in quantities sufficient to produce a flushed skin, it is pretty safe to say that its secondary abnormal effects have begun."

20. Alcoholics comprise, principally, *malt liquors* (ale, beer, porter, and stout); *wines* of various kinds; and distilled liquors, or *spirits* (whiskey, rum, gin, and brandy). There are also other powerful alcoholics, such as the cordials and liqueurs, and milder ones, such as fermented cider, kumyss, and beers made from roots. All of these fluids contain alcohol in varying amounts. Those which contain the least — *i.e.* from 1 to 9 per cent — are kumyss,[1] cider, beers, ales, and light wines, such as claret; heavier wines, such as sherry and port, contain 17 to 20 per cent; wines which have been "fortified," *i.e.* had spirits added, have as high as 35 per cent; while spirits contain 50 per cent or more.

Malt liquors are made from grain (principally barley), germinated by heat and moisture, — then known as "malt,"

[1] Kumyss, as used in this country, is fermented cows' milk, and contains from 1 to 2½ per cent of alcohol.

— to which is added water, yeast, and flavoring substances. While it is true that the malt, together with some of the nourishing elements of the barley or other grain, if used occasionally, acts as a tonic, the world abounds in other substances that tone up the system, and which are not likely to be followed by depression or degenerative processes. Habitual drinkers of malt liquors, imbibing as they do considerable alcohol and very much water, are likely to become bloated from the thinning of their blood, to accumulate unhealthy fat, to become logy and stupid, and to be more susceptible to diseases.

Wines result from the fermentation of the sugary juices of crushed or broken fruit by contact with bacteria in the air and on the skins of the fruit. Like the juice of apples (cider), wines at first contain but little, if any, alcohol, and are "sweet"; but as fermentation proceeds, their character is changed. Old cider, which contains considerable alcohol, and is known as "hard," is as intoxicating as some of the spirits. Light wines, ordinary cider, ginger beer, and similar drinks act as excitants of the nervous system. Frequent resort to them induces artificial tastes and appetites, and a desire for the stronger stimulation that heavy wines and spirits afford. In France, which a few years ago was considered a pattern for the use of light wines, alcoholism has become very common, so that the government is investigating the ravages caused by alcohol.

Spirits are distilled from wines, fermented molasses, fermented juice of the sugar-cane, malt, cider, fruit juices, or other materials. Cordials and liqueurs are spirits mixed with syrup and flavoring essences. These alcoholics tend to impair the functional activity of cells, and to cause thickening and contraction of the connective tissue of the

liver, kidneys, and brain. A great and unnatural craving is often generated by their repeated use, so that men will drink with avidity alcohol in which are decomposing materials, or the bitterest substances, such as quinine, or will drain at one gulp the vilest and strongest liquor, without any attempt at dilution.

21. General Facts as to Alcohol and Alcoholics.

First. Pure alcohol is a powerful poison.

Second. The tendency of alcohol in alcoholic liquids, if they are used repeatedly and for a considerable time, is to act as poison, viz. to inflame, impair, or destroy cell protoplasm; to harden and shrink albuminous tissues; to produce an undue amount of fat, some of which replaces muscular tissue, as in the heart; to subtract heat from the body; and to depress nervous energy.

Third. Alcoholics are not needed by persons in health, and when used medicinally should be prescribed by physicians only, as are other potent remedies or drugs, such as opium. The practice of resorting to alcoholics for the relief of slight ailments is apt to end in drunkenness.

Fourth. Their use, even in moderate amount, by persons of a nervous temperament, or in whom there may be an hereditary tendency to the drink habit, is likely to be followed by an intense craving for them. No one, whatever his temperament may be, can tell, when he begins to use them, whether or not he will succumb to their influence. Alcohol is a thing the use of which carries with it the temptation to abuse.

Fifth. Even persons with strong powers of self-control are not safe from the danger of forming the alcoholic appetite, for alcohol possesses the power of very frequently impairing that function of the mind known as self-

restraint. The man with weak will power is readily overcome by this insidious adversary. Unfortunately, persons with strong self-control, who do not themselves drink to excess, may cause those of weak will to drink immoderately, by associating with them and drinking in their presence.[1]

22. **Tobacco** is another substance which is largely used and also abused. Its moderate use may not apparently affect certain adults unpleasantly,[2] but the moderate use is apt to become immoderate. For persons of a nervous temperament it is usually harmful. The young should never use it, as their tissues are more delicate than those of adults, and their power of resisting the evil effects of all such agents is much less. It has been truly said, "there is no such thing as moderation in cigarette smoking."

The active ingredient of tobacco, — nicotine, — like alcohol, has a subtle power. It tends to induce the tobacco habit. This subtle power of arousing an appetite or intense desire for the substance used is peculiar also to other drugs, such as opium, chloral, and cocaine. No such appetite is ever aroused by the use of water, milk, cocoa, or any complete food.

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[1] It is stated that Dr. Woolsey, formerly president of Yale College, made the following reply to the question, "If a young man should come to you for advice as to the use of wine, what would you say to him?": "I should tell him not to allow himself to have any drinking habits; I should not advise him to pledge himself not to drink, but to abstain from principle. It is not necessary to regard drinking a glass of wine as a sin in itself, but every young man should see that it is better for himself, and especially for weak associates who may be under his influence, to use no strong drink, and therefore he should decide not to indulge."

[2] Experience has shown that under certain circumstances, as with overworked and tired soldiers on a march, it arouses their dormant energies.

The habitual use of tobacco is likely to produce an irritable condition of the heart and brain, to destroy the appetite, to decrease the digestive secretions, and to seriously impair the health. "It is a pity that boys think it manly to smoke and that students allow themselves to be greatly influenced by the custom of their fellows." It is a deplorable fact that cigarette smoking is increasing, owing to the cheapness of cigarettes and their open sale. Within the last few years, murders and other heinous crimes have been committed by boys and young men, so-called "degenerates," the victims of confirmed cigarette smoking. The report of a special navy medical board, to the superintendent of the United States Naval Academy,[1] "On the Use of Tobacco by the Cadets," states that "Even when used in small amount, the capacity for study and application is lessened by headache, confusion of intellect, loss of memory, impaired power of attention, lassitude, indisposition to muscular effort, nausea, want of appetite, dyspepsia, palpitation, tremulousness, disturbed sleep, impaired vision, etc."

"It is no uncommon practice for young men who smoke cigarettes habitually, to consume from eight to twelve in an hour, and to keep this up for four or five hours daily. The total quantity of tobacco may not seem large, but, beyond question, the volume of smoke to which the breath organs of the smoker are exposed and the characteristics of that smoke as regards the proportion of nicotine introduced into the system combine to place the organism very fully under the influence of the tobacco. A considerable number of cases have been brought under our notice during the last few months, in

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[1] December 3, 1875.

which youths and young men who have not yet completed the full term of physical development have had their health seriously impaired by the practice of smoking cigarettes almost incessantly. It is well that the facts should be known, as the impression evidently prevails that any number of these little 'whiffs' must needs be perfectly innocuous, whereas they often do infinite harm. A pulse-tracing, made after the subject has smoked a dozen cigarettes, will, as a rule, be flatter and more indicative of depression than one taken after the smoking of cigars."[1]

23. Opium, Cocaine, etc. — Other substances besides alcohol and tobacco that are largely used for their exciting or their narcotic[2] effects are opium, cocaine, caffeine, coca, and the betel nut. The habitual use of any of them creates a desire for more, and decreases the appetite for food. Opium is the most seductive of them all. "By its soothing and exhilarating influence it gains such a hold on the moral and physical nature that the strongest will is unable to emancipate the victim from its enchantment." Its frequent use in cough mixtures, soothing syrups, cordials, carminatives, and other compounds interferes with the assimilation of food and enervates the system. The

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[1] *The London Lancet.*

The evil effects of cigarettes are due in part to the fine shredding of the tobacco, in part to the combination of paper with tobacco, the more direct relation of the nicotine with the mouth and air passages than when tobacco is smoked in a pipe or cigar, the frequent inhalation of cigarette smoke and its retention for a time in the air passages, and, finally, to the fact that the habit of cigarette smoking is usually begun by young children, though there is a law against selling cigarettes to children under sixteen years of age.

[2] Narcotics are substances which have the property of stupefying.

same effects follow the use of chloral, caffeine, etc.,—substances too frequently employed without reason or discrimination.

QUESTIONS.

1. What is to be gained by the study of anatomy, physiology, and hygiene?
2. Define these three topics.
3. What is health?
4. What is its value to individuals and communities?
5. What is the general arrangement of the human body?
6. What are cells, and what is meant by cell life?
7. What properties are distinctive of live matter?
8. Name the phases through which life passes.
9. Name some of the tissues and fluids of the body.
10. What are the sources and objects of animal heat?
11. What are the chemical components of the body?
12. What are bacteria and disease germs?
13. What are the methods used to produce immunity from infectious diseases?
14. What is alcohol — how obtained?
15. What are alcoholics? Name the several classes.
16. What are some of the evil effects of alcohol in varying amounts?
17. What are the dangers of tobacco?
18. What is the "tobacco habit"? What is the danger of cigarette smoking?
19. What is said as to the use of opium, cocaine, and other narcotics?

CHAPTER II.

BONES AND JOINTS.

24. **The Use and Number of Bones.** — The general figure and stability of the human body are maintained by the bones. Associated with cartilages[1] and ligaments they form the framework, or skeleton.[2] In the entire skeleton of an adult there are two hundred distinct bones.[3] The relations of these to one another are shown in Fig. 6.

25. **Shape of Bones.** — The bones vary in form, and though they are more or less irregular, they may be considered as long, short, or flat.[4]

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1 Sometimes called "gristle."

2 Skeletons usually seen in museums and lecture rooms are sometimes called artificial skeletons, because cartilages and ligaments are replaced for the most part by wire, leather, and chamois skin.

3

Bones of the spinal column	26
The cranium (skull)	8
The face	14
Ribs, hyoid bone, and breast bone	26
The upper extremities	64
The lower extremities	62
Total	200

This enumeration includes the patellae (knee pans), but not the teeth, small bones of the middle ear, or certain small bones having the form of seeds (*sesamoid*), situated in the tendons or strings of certain muscles, where unusual pressure is exerted. Neither does it include certain supernumerary bones, called *Wormian bones*, found in incomplete joints of the skull. Teeth differ from bones in structure, development, and mode of growth.

4 Examples of the more irregular bones are the hyoid, to which the tongue and larynx are attached, the vertebrae, or most of the bones of the

The *long bones* are hollow shafts with two extremities, called *heads*, which are generally expanded, the better to form joints and to afford increased surface for the attachment of muscles and ligaments (Fig. 6, right leg). "They represent columns for supporting the weight of the body, or levers of different kinds for the muscles to act upon." The long bones are the clavicle (collar bone), the humerus (arm bone), the radius and ulna (forearm bones), the femur (thigh bone), the tibia and fibula (leg bones), and some of the bones of the hands and feet.[1]

The *short bones* are located in those parts of the body where strength, compactness, and elasticity are required. They are strongly bound together by ligaments. Examples of short bones are found in the wrist and ankle.

The *flat bones* afford broad surfaces for muscular attachment, and serve to protect important organs. They are the shoulder blades, breast bone, ribs, hip bones, and some of the bones of the skull.

26. The Surfaces of Bones. — On the surfaces of bones are various eminences[2] and depressions.[3] The first afford attachment for muscles, tendons, and connective tissue; the latter, safe and convenient passages for blood-vessels, nerves, tendons, and muscles. Through the surfaces of the bones are openings for the passage of blood-vessels,

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spinal column, and some of the bones of the skull. These last are the temporal, sphenoid, ethmoid, superior maxillary (upper jaw), inferior maxillary (lower jaw), the palate bones in the roof of the mouth, and the inferior turbinated bones in the nose.

[1] These last are the phalanges, or bones of the fingers and toes, and the metacarpal and metatarsal bones, *i.e.* bones connected with the carpus, or wrist, and tarsus, or ankle.

[2] Tuberosities, tubercles, spines, and ridges.

[3] Grooves, furrows, fissures, and notches.

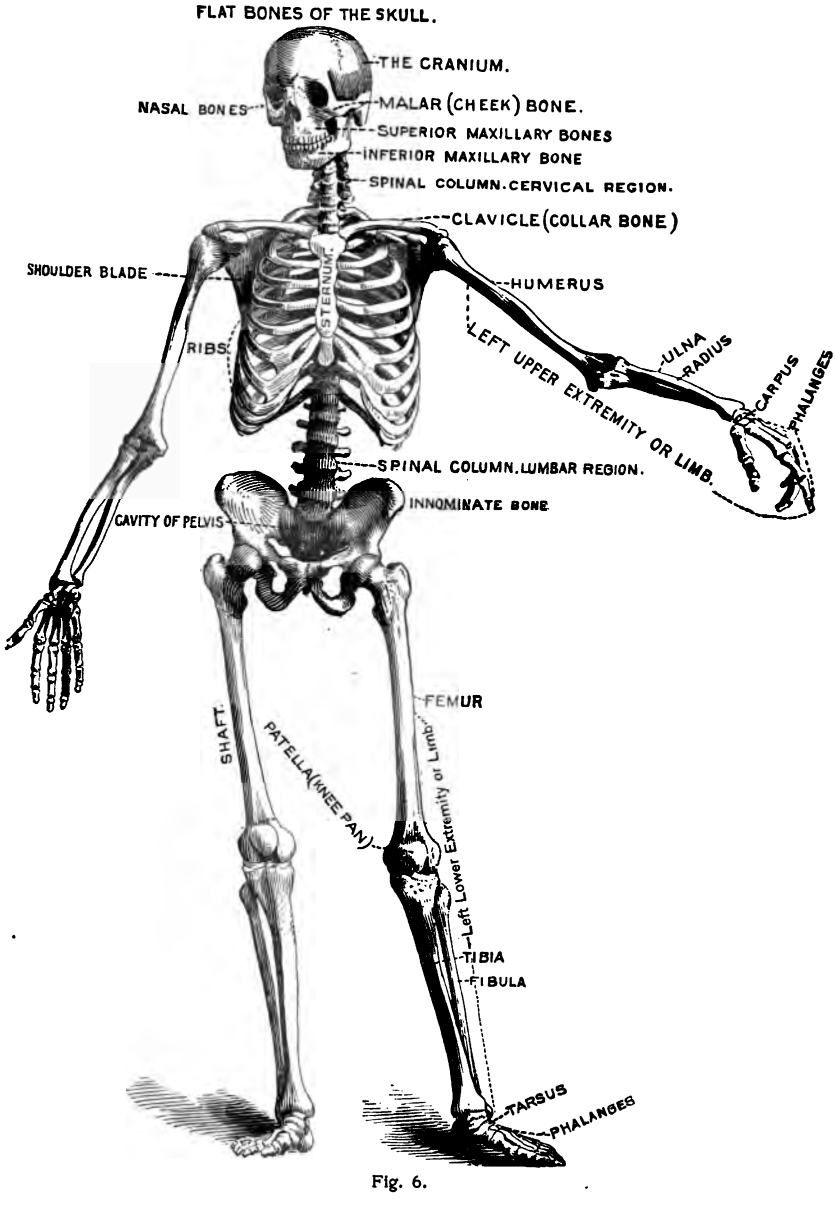
FLAT BONES OF THE SKULL.
THE CRANIUM.
NASAL BONES
MALAR (CHEEK) BONE.
SUPERIOR MAXILLARY BONES
INFERIOR MAXILLARY BONE
SPINAL COLUMN. CERVICAL REGION.
CLAVICLE (COLLAR BONE)
SHOULDER BLADE
STERNUM.
HUMERUS
RIBS
LEFT UPPER EXTREMITY OR LIMB.
ULNA
RADIUS
CARPUS
PHALANGES
SPINAL COLUMN. LUMBAR REGION.
INNOMINATE BONE
CAVITY OF PELVIS
FEMUR
SHAFT.
PATELLA (KNEE PAN)
Left Lower Extremity or Limb
TIBIA
FIBULA
TARSUS
PHALANGES

Fig. 6.

nerves, etc. These openings are especially numerous at the extremities of long bones.

All bones are enveloped in a firm vascular[1] membrane (the *periosteum*), except on the surfaces of joints, where they are overlaid with a smooth elastic tissue, known as *cartilage*. The periosteum clings closely to the bone and nourishes it, and is capable, with the aid of the surrounding soft tissues, of producing new bone to replace that removed by disease or by surgical operations.[2] Bones die when deprived of periosteum.

Fig. 7.

Posterior View of Femur, showing the ridges, depressions, and openings.

Fig. 8.

Longitudinal Section of Femur, showing the compact and cancellous tissue of bone.

27. Structure of Bones. — If a bone be sawn across, its walls will be found to be very hard and strong, like ivory. This firm tissue is called the *compact tissue*. In a long bone it is thicker in the middle of the shaft than at the extremities, where it disappears in a fine network tissue, called the

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[1] Full of blood-vessels.

[2] Hence the surgeon, in removing dead bone, removes as little of the periosteum as possible, and thus has succeeded, with the aid of nature, in producing new lower jaws, and even arm bones.

spongy or *cancellous tissue.*[1] The size of the bone along the shaft, where the strength is mainly required, is thus diminished; while at the ends the extent of surface which is needed is obtained without increase of weight.[2] The more expanded and elastic spongy tissue serves also, both at the extremities of the long bones and in the

Fig. 9.

Radiograph (X-ray) of Head of Thigh Bone, showing arched structure and cancellous tissue. (Dr. J. Sherman Wight.)

interior of the other bones, to deaden the force of concussions. It is ordinarily filled with the oily material known as *marrow*, which also fills the hollow shaft or tube of the long bones. This tube or central canal is therefore called the *medullary canal* (*i.e.* marrow canal).

[1] The tubular character of long bones with compact walls affords lightness and strength. The same principle is observed in stalks of grain and in the construction of bicycle frames.

[2] Pupils in the engineering school at Zurich use the section of the head of a thigh bone for the study of ideal stress lines for bridges.

It is lined with a vascular web of connective tissue, known as the *medullary membrane*, which nourishes the inner parts of the bone. The marrow in the spongy tissue of bones is of a red color, and is called red marrow, to distinguish it from that of a yellow color in the hollow

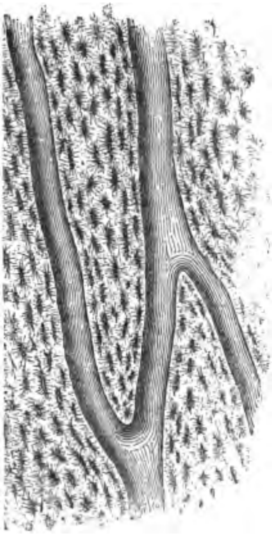

Fig. 10.

Longitudinal Canals in Compact Tissue of Bones, with their connecting canaliculi and the lacunae. (Magnified 200 diameters.)

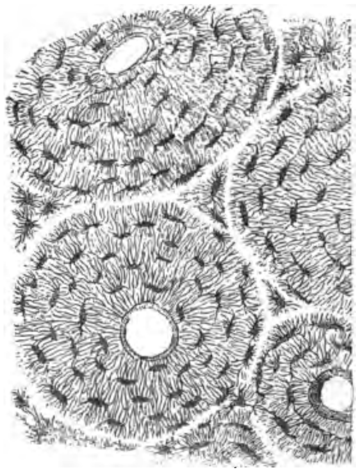

Fig. 11.

Transverse Section of Compact Tissue of Bones, showing openings of longitudinal canals, the canaliculi, and the lacunae. (Magnified 200 diameters.) The fine lines are canaliculi; the dark spots are lacunae.

shafts of adult bones. The red marrow is one of the sources of the red blood corpuscles.

Even the compact tissue, solid as it appears to the eye, is found, under the microscope, to contain numerous vascular canals. The larger of these run lengthwise with the bones, and are connected with one another and with the periosteum and medullary membrane by slightly oblique

transverse canals, in the course of which are enlargements or small reservoirs.[1] In addition to blood vessels, nerves are found in bones, and, according to good authorities, also lymphatics.[2]

28. Nutrition of Bones. — Bones are nourished by the same means as other and softer tissues, and like them have the power of assimilation. Pupils are apt to judge of bones in the living body by the dried specimens in lecture rooms and museums; but they are as unlike as the green and the dead twigs of a tree. A bone of an animal recently killed will be found to have a pinkish, pearly-white hue, due to the blood it contains.

In very early life bones are soft and cartilaginous. Gradually they become harder, cartilage being replaced by bone, as food supplies the necessary phosphatic salts. If proper food is not supplied during the growth and development of children, their bones may become so soft and flexible as to be distorted readily by muscular contraction or by weights which they would normally sustain. This diseased condition is known as *rickets*.

29. Strength and Elasticity of Bones. — Bones are composed of *animal matter*, mostly gelatine, and *mineral matter* (bone earth), chiefly calcium phosphate.[3] The animal

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[1] The longitudinal canals are called *Haversian* canals, from Clopton Havers, their discoverer; the transverse canals, *canaliculi*; the reservoirs, *lacunae*. The Haversian canals, the canaliculi, and the lacunae together constitute the Haversian system of canals.

[2] Lymphatics are vessels that carry lymph. Bones are generally not very sensitive; but when inflamed they become acutely sensitive, the nerves being pressed upon in their bony canals by the products of inflammation.

[3] If a bone be immersed in a dilute acid (muriatic, for instance) for a sufficient time, the mineral matter will be dissolved, while the animal

matter renders bones tough and elastic, enabling them to bear ordinary shocks without injury, while the mineral matter makes them hard and rigid, capable of sustaining weights and strains without change of shape. Professor Robinson found that a piece of bone one inch square bore a weight of five thousand pounds without breaking.[1]

In youth, the animal matter constitutes more than one-third of the bone substance; hence the bones of children are more elastic than those of adults, and less likely to be broken.[2] As the child grows, the bones become stronger, and are thus adapted to the increasing muscular strength. In adult life, mineral matter constitutes two-thirds of the bone substance. The bones are then very strong, though retaining considerable elasticity. In old age, the bones become brittle from an excess of mineral matter, and are likely to break from slight causes. An aged person, incautiously stepping even from a footstool or from a curbstone, may break his thigh bone. Sometimes bones become brittle as the result of disease.

30. Joints.—The junction of two or more bones constitutes a joint, or, more technically, an *articulation*.

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matter will remain in the perfect shape of the bone, which may now be bent, or even tied in a knot. If a bone be exposed to the action of fire, the animal matter will be burned out, and the substance remaining in the shape of the bone will crumble when touched.

[1] "Bone has been found by experiment to possess twice the resisting property of solid oak. It is also elastic, as is shown by the resiliency of the fibula when its shaft is pressed against its tibia; and by Mr. Ward's experiment of placing the clavicle at right angles against a hard body, and striking the free end a smart blow with a hammer, when the bone will rebound a distance of two feet."—G. M. HUMPHREY, *Treatise on the Skeleton*.

[2] Bones of children are apt to be bent by prolonged and repeated weight and strain upon them.

Joints are classified as *immovable*, *mixed*, and *movable*. The joints of the cranial bones,[1] called ***sutures*** or ***dovetail joints***, are immovable;[2] those of the vertebrae are mixed. Most of the other joints of the body are movable. The varieties of these are the ball and socket joints, of which the shoulder and hip are examples; and hinge joints, to which class the knee and elbow belong.

Fig. 12.
Suture Joints of the Skull.

Fig. 13.
Hip Joint (Ball and Socket).

31. The skull rests and nods upon the first vertebra, or *atlas*. It also rests upon a tooth-like process of the *axis*, or second bone of the spinal column, which projects upwards through a hole in the atlas and forms a pivot, or

[1] Upper bones of skull (Fig. 12).

[2] The upper bones of the skull of a baby do not unite until months after birth, in order to allow the brain to grow. The dovetail joints later in life fasten these bones together very firmly, so that an adult can carry considerable weight upon the head without injury.

swivel, upon which the head rotates, or turns from side to side, the atlas also turning with it.

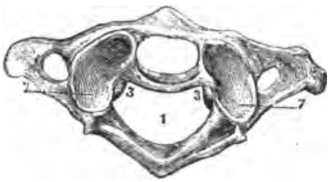


Fig. 14.
The Atlas.

1, opening for spinal cord.
3-3, transverse ligament, inclosing, with the bone, an opening for part of axis to pass up through.
7-7, resting places for prominences on skull.

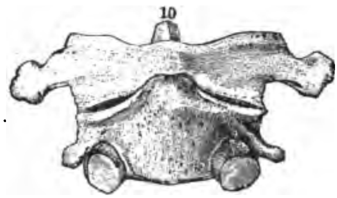


Fig. 15.
Atlas and Axis in position.

10, projection of axis, passing through the atlas, upon which the skull rests.

32. Structure of Joints.—The bones of most of the joints are held together by strong bands of fibrous connective tissue, called *ligaments*. Their connection is

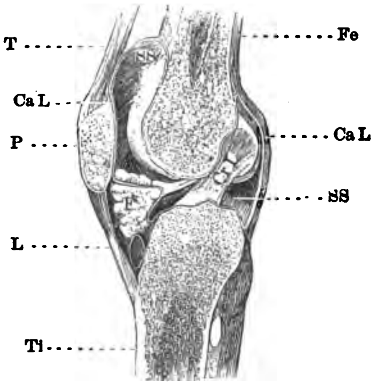
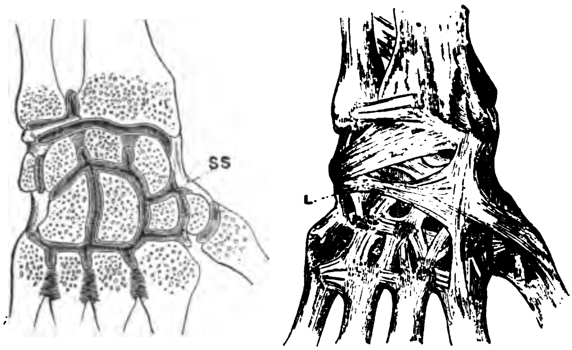


Fig. 16.
Longitudinal Section of Knee Joint, showing the relation of the structures which enter into its composition.

T, tendon.
SS, synovial sac.
Fe, femur.
Ca L, capsular or enveloping ligament.
P, patella or knee pan.
F, fat.
L, ligament of patella.
Ti, tibia.
Cr L, crucial or cross-shaped ligament between the ends of the femur and tibia.

further strengthened by muscles and tendons, and also, in some degree, by the enveloping fat and skin. The articular surfaces of these bones are protected from friction by thin shields of firm, elastic tissue, called *cartilage*, and, in the movable joints, by the synovial[1] membranes which line their cavities and which pour into the joints, as it is needed, a lubricating substance called the ***synovial fluid.*** The elasticity of these cartilages serves to diminish shocks



A Fig. 17. B

A. Longitudinal section of wrist joints, showing the synovial sacs and membranes (SS).
B. Ligaments of wrist joint (L).

from walking, running, jumping, etc., thus protecting the delicate structures of the body from injuries which would otherwise result.

33. Injuries to Joints.—*Sprains* are the violent straining or twisting of one or more of the structures of a joint. So serious, sometimes, is the injury that a sprain is spoken of as a broken joint. A *dislocation* is a bone out of place, and is often associated with the tearing or bruising of

[1] So called from the synovia or adhesive fluid within it.

joint tissues. The treatment of sprains, as well as of dislocations and fractures, should be under the direction of a physician.[1]

QUESTIONS.

1. Of what use are bones?
2. How many are there in the body? How classified?
3. Describe the long bones, and explain the use of their length.
4. Where are the short bones located?
5. What is the special use of flat bones?
6. Why are there eminences and depressions upon bones, and why openings through them?
7. What is the periosteum, and of what use is it? the cartilage?
8. Of what kinds of tissue are bones constructed? Describe these tissues and their respective uses.
9. What and where is the marrow? the medullary canal the medullary membrane?
10. Of what are bones composed?
11. Of what different uses are the animal and mineral matter of bones? What results from an excess or a deficiency of either?
12. How do the bones of the young and old differ?
13. How are bones nourished, and what do they contain?
14. What is a joint, or articulation, and how are joints classified?
15. How are the nodding and rotating motions of the head effected?
16. What protects the joints from friction?
17. How is the liability of the delicate structures of the body to injury from shocks in jumping, etc., diminished?
18. How are the bones held together, and what is a dislocation?

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[1] For further information, see Emergencies, pp. 391 and 393.

CHAPTER III.

THE SKELETON.[1]

34. Its Uses. — The skeleton is beautifully adapted to support weight.[2] It affords surfaces for the attachment of muscles, and thus facilitates the movements of the body. It incloses cavities for the lodgment and protection of the eyes, heart, lungs, brain, and other important and delicate organs.

35. The Spinal or Vertebral Column.[3] — This is the main support of the body, and in the adult consists of 26 bones, 24 of which are called *vertebrae*.[4] The two lowest bones

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[1] The skeleton of man is an internal or endo-skeleton, that of the oyster or lobster an external or exo-skeleton. The turtle has both an internal and an external framework. The sturgeon, besides an endo-skeleton, has an irregular outer case of superficial bony plates (dermo-skeleton), which enables the fish to swim more safely in search of food among rocks and debris.

[2] At twenty-one years of age the weight of the human skeleton is about *one-tenth* that of the entire body. It averages about 15 lbs., yet is capable of sustaining great weights, and can at times be subjected to great strains without injury. Dr. Winship, a celebrated athlete, though a small man, could lift a weight of 2500 lbs.

[3] It is commonly called the *backbone*, as though it were a single bone.

[4] From the Latin *vertere*, "to turn." They turn, or rotate, and at times incline forward, backward, or to either side, in the varied movements of the body. In the neck, or cervical region, there are *seven* vertebrae; in the back, or dorsal region, *twelve;* and in the loin, or lumbar region, *five*. The sacrum and coccyx are sometimes called false vertebrae, for in very early life the first is composed of five rudimentary vertebrae, and the second of four. Hence, the number of bones in the spinal column is sometimes stated as 33.

are the *sacrum* and *coccyx*. The spinal column not only serves to bear the weight of the upper part of the body, but maintains it in proper relation with the lower part (Fig. 6). Its lower end fits in like a wedge between the hip bones, and unites with them to form the pelvis. Take the backbone away, and the skeleton collapses.

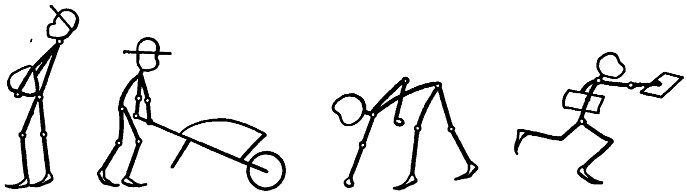

Fig. 18.

"Backbone Pictures," showing dependence of body upon the spinal column.

36. Vertebrae. — Each vertebra is composed of a disk-like body with a bony arch projecting backward from it, and is tunnelled by a large opening through it extending up and down, or longitudinally with the body. The vertebrae are united by strong ligaments, and are so placed that the openings through the several vertebrae form one long tube or tunnel, called the *spinal canal*, which serves for the lodgment and protection of the *spinal cord.*[1] Nerves pass to and from this canal, through notched apertures in the sides of the various vertebral arches. The posterior projections (spines) of the arches form the ridge which may be felt extending along the middle of the back. To diminish the shock of jars and falls, there are cushions of very elastic cartilage between the vertebrae.

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[1] A cord-like arrangement of nerves (that is, many strands of nerves united together in one cord), which connect the brain with other parts of the body, by means of branches sent out through the spinal openings mentioned in the text.

37. Curves of the Spinal Column. — The vertebral column has four curves, — the *cervical*, *dorsal*, *lumbar*, and *sacral*. Two are forward curves, and two backward. These are so nicely adjusted that their relative positions are ordinarily maintained, whatever the movements of the body may be. Hence, pressure is better distributed than would be the case if the column were straight. Still, jumping from a height upon a resisting surface, heavy blows or falls, and the prolonged and excessive action of special muscles or groups of muscles frequently produce spinal deformities and disease.[1] The custom, too common among school children, of carrying a number of books on the same arm tends to produce lateral curvature of the spine. The man who habitually carries a pack on one shoulder becomes deformed (*a*).

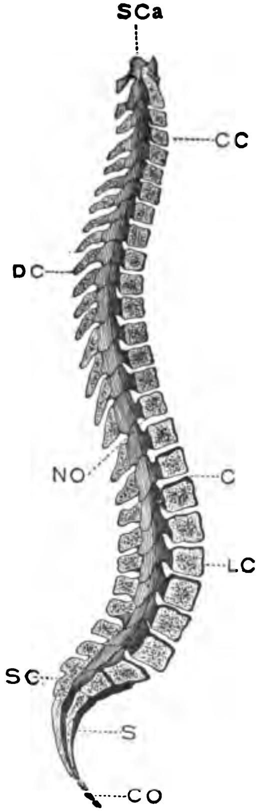

Fig. 19.

Longitudinal Section of Spinal Column.

CC, cervical curve.
DC, dorsal curve.
LC, lumbar curve.
SC, sacral curve.
SCa, spinal canal.
NO, opening for nerves.
C, location of intervertebral cartilages.
S, sacrum.
CO, coccyx.

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[1] Spinal curvatures are liable to result from habitual sitting, standing, or even lying in wrong positions. The habit of bending over to study, write, or use the sewing-machine is injurious. When standing, the body should be erect, the shoulders held back in an easy, comfortable manner. When sitting, the body or head should be bent but slightly forward. Constrained positions are always injurious.

38. The Ribs. — Branching out from each side of the spinal column, in the dorsal region, are the twelve *ribs*, which are grooved underneath for the passage of blood-vessels and nerves to the front of the body. The ribs slope downward and outward, and, with the dorsal vertebrae and breast bone, form the bony walls of the thorax or chest. This arrangement and the elasticity of the cartilages which unite most of the ribs to the breast bone permit considerable enlargement of the chest cavity in the process of breathing.[1] Free movements of the chest walls are necessary for the health and proper action of the organs within them.

Fig. 20.

Lateral Curvature of Spine, caused by the habit of carrying books on one arm. (MOSHER.)

39. The Pelvis. — This consists of the sacrum and coccyx behind, the hip bones (innominate bones) upon the sides, and the pubic bone in front. By its size, strength, curves, and expanded upper edges (hips), it is well adapted to support and protect the organs within it. It also assists in supporting the upper part of the body, by its relation

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[1] The seven upper ribs upon each side are joined directly to the breast bone by cartilages, and are called *true* ribs; the other five are called *false* ribs. Of these five the three upper ones are joined by cartilages to the cartilages of the true ribs, while the two lower, having no cartilages, their anterior ends being free, are called *floating* ribs.

to the spinal column and by the attachment which it affords for the powerful muscles of the trunk. Articulating (forming joints) with the pelvis are the two thigh bones. These are supported by the bones of the legs, which in turn rest upon those of the feet.

40. The Limbs, or Extremities. — These are joined to the trunk at its upper part by means of the shoulders (collar bones and shoulder blades), and at its lower portion by the hip bones. The bones of each upper extremity are the humerus (arm bone), radius and ulna (forearm bones), and the bones of the hand.[1] Each upper extremity is so arranged that the hand may be freely used.[2] The lower extremities have less mobility than the upper, but more strength, since they bear the weight of the body. The bones of each lower extremity are the femur (thigh bone), tibia and fibula (leg bones), and the bones of the foot.[3]

41. The Bones of the Foot. — The bones are arranged in the form of an arch, the forward part of the foot and the heel only resting upon the ground. This arched form secures great elasticity, and diminishes the shocks to other

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[1] The hand includes the bones of the wrist, palm, and fingers.

[2] The arm bone is longer than the forearm bones, and the forearm bones are longer than those of the hand. This arrangement, together with very pliable fingers and with the thumb, which can readily be opposed to all the fingers, characterizes man as distinct from and above all other forms of animal life.

[3] The foot includes the bones of the ankle, instep, and toes. The mobility of the toes and their power to grasp objects are very much increased by their frequent use without the restriction of shoes, as has been noticed among certain savage tribes. Persons born without hands have learned to write, to use a knife and fork in eating, and to thread a needle with their toes.

parts of the body in the acts of walking, running, and jumping. It also affords a more secure footing in walking and running over uneven ground, in climbing ladders, etc.[1]

Fig. 21.
Bones of the Foot and their Relative Location.

42. The Principal Closed Cavities of the Skeleton. — These are three in number, viz. the *cranial*, *thoracic*, and *pelvic* cavities.[2] Within the *cranial cavity* are the brain and the beginning of the spinal cord, and also nerves and blood-vessels.

The *cranium*, or *skull*, is a rounded bony box, admirably constructed for its particular use.[3] It has a vaulted dome, side walls, and very strong buttresses in the temporal bones, which inclose the delicate organs of hearing.

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[1] The elastic arch of the foot assists largely in graceful movements of the body, if it is not hampered by improper footgear. When the ligaments of the arch have lost their tone, the foot is known as a "flat foot," and walking becomes difficult.

[2] In addition to these cavities and the marrow cavities of long bones, there are cavities which contain air, such as the frontal sinuses in the frontal bones of the skull, which open into the upper part of the nose; the antrum, in each half of the upper jaw; and the sphenoidal and ethmoidal sinuses, in the sphenoid and ethmoid bones. These reservoirs of air are concerned in the processes of breathing and in the production of voice, and serve to lighten the weight of bones.

[3] The tissue of which the flat bones are composed is arranged in layers, or tables. On account of their character, these were by the ancients likened, the outer one to wood, the middle one to leather, and the inner one to glass (from its smoothness).

The base is formed of bones strongly wedged in together, with openings so arranged that the delicate blood-vessels and nerves passing through them are not easily injured.

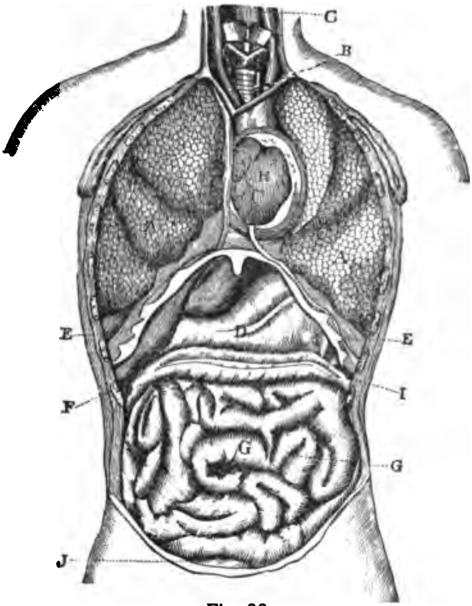


Fig. 22.

Front View of the Contents of the Cavities of the Chest and Abdomen.

B, trachea. C, oesophagus. E, diaphragm. F, liver. I, spleen. D, stomach. G, intestines. H, heart. A, lungs. J, bladder.

43. The Thoracic Cavity.—This extends from the base of the neck above to the diaphragm[1] below, and from the spinal column and ribs behind to the breast bone and the cartilages of the ribs in front. It contains the lungs, the heart, some large blood-vessels, nerves, the thoracic duct, and the oesophagus, or gullet.

[1] A strong muscular and tendinous partition dividing the thoracic from the abdominal cavity (Fig. 23).

44. The Pelvic Cavity. — This is the space inclosed by the pelvic bones. It contains the bladder, the lower end of the large intestine, and other viscera.

Between the thoracic and pelvic cavities is a fourth cavity, the *abdominal*, which is partly inclosed by bony walls and partly by muscles. It contains the liver on the right side, the stomach and spleen on the left, the intestines in front, and the pancreas, kidneys, receptacle for chyle, and very large blood-vessels and nerves behind.

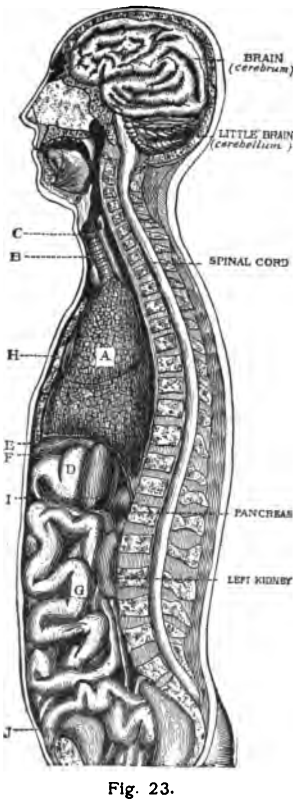


Fig. 23.

Side View of the Head and Trunk; the bones and soft coverings of the cavities being removed, and the face, throat, and spinal column given in longitudinal sections. The organs are in relief.

A, lungs. B, trachea. C, oesophagus. D, stomach. E, diaphragm. F, a small portion of the liver. G, intestines. H, heart. I, spleen. J, bladder.

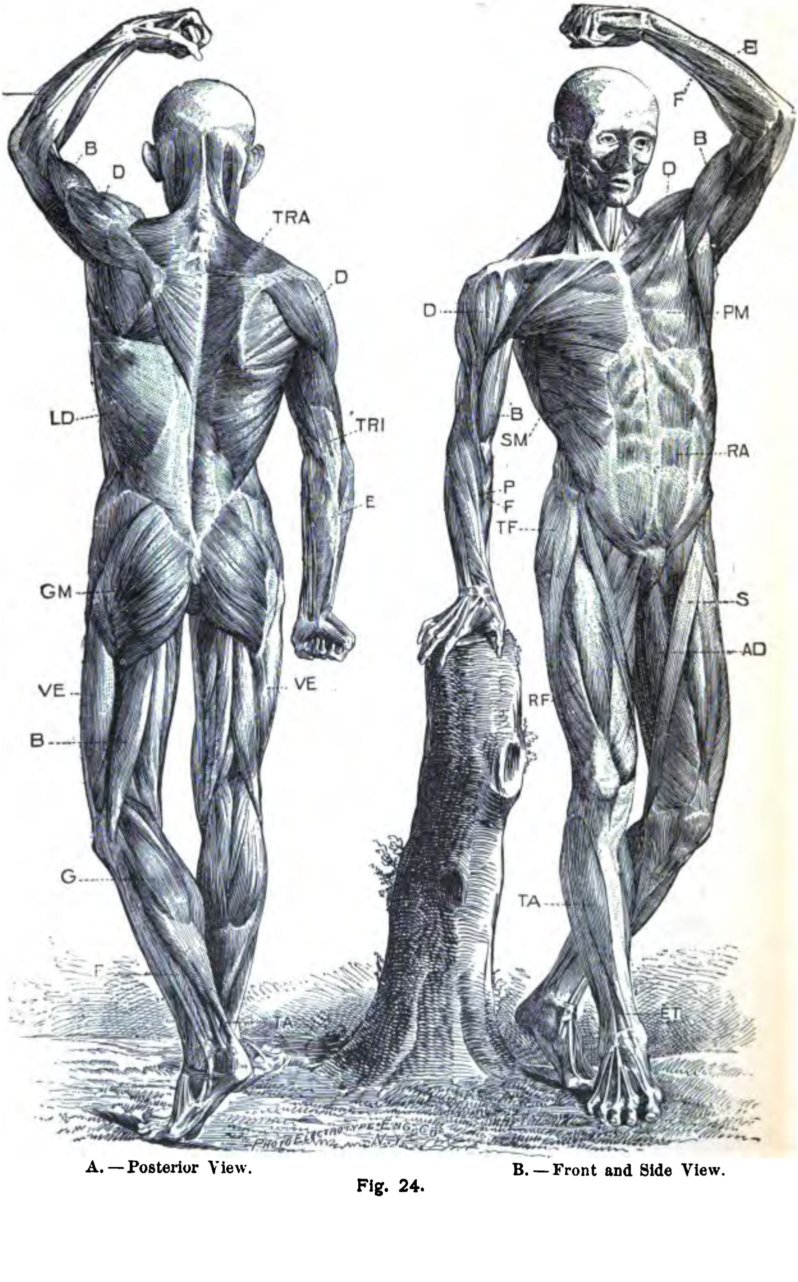
45. Effects of Alcohol upon Bones. — The specific evil effects of alcohol upon the tissues and organs of the body, either in derangement of their function or change of their structure, have been specially studied by scientists in connection with the muscles, skin, stomach, liver, kidneys, blood, and nervous system. Very little is known of any specific effects of alcohol upon bones and joints. It is believed that blood containing it, if brought repeatedly to these parts, interferes with their growth and develop-

ment, especially in the young, by hampering the activity of the various cells which enter into their composition. Fothergill states that "alcohol is used to limit the growth of jockeys and pet dogs." It is a fact well recognized by surgeons that broken bones of drunkards unite with great difficulty.

As to *tobacco*, *opium*, and the other narcotics, no specific effects upon bones and joints are known.

QUESTIONS.

1. Of what service is the skeleton?
2. What is the use of the skeleton, and what is its main support?
3. How is the spinal column fitted to the hip bones, and of what does it consist?
4. Describe the vertebrae. How they are separated from each other, and why?
5. How is the spinal canal formed, and what is its purpose?
6. How do the nerves of the body reach it?
7. What curves has the spinal column, and what is their object?
8. Describe the ribs, and explain the object of their downward slope.
9. Of what bones does the pelvis consist, and what is its use?
10. Describe the lower portion of the skeleton.
11. How are the bones of the feet arranged, and why are they so arranged?
12. Of what bones does each upper extremity, or arm, consist, and what is the object of their arrangement?
13. What are the bones of the lower extremities?
14. What cavities are in the skeleton?
15. Describe the cranium, and mention its contents.
16. Describe the thoracic cavity, and mention its contents.
17. What cavity is above the pelvic cavity, and what are its contents?
18. What is said as to specific effects of alcohol, tobacco, opium, etc., upon bones?



A.—Posterior View.

B.—Front and Side View.

Fig. 24.

Fig. 24.

MUSCLES OF THE BODY. *Superficial layer.*

A.

E, extensors of the hand.
B, *biceps* muscle, flexor of arm and forearm.
D, *deltoid*, raises the arm and moves it backwards and forwards.
TRA, *trapezius*, draws back and raises shoulder.
TRI, *triceps*, extensor of forearm.
LD, *latissimus dorsi*, assists in respiration by moving the ribs.
GM, *gluteus maximus*, moves the thigh backwards and outwards.
VE, *vastus externus*, extends the leg.
B, *biceps* of thigh, flexor of leg.
G, *gastrocnemius*, extends the foot.
F, flexors of the foot.
TA, *Tendo Achillis*.

B.

E, extensors of the hand.
F, flexors of the hand.
B, *biceps*, etc.
D, *deltoid*, etc.
PM, *pectoralis major*, draws the arm forwards and inwards.
P, *pronator*, rotates forearm inwards.
SM, *serratus magnus*, assists in respiration.
RA, *rectus abdominis*, that makes tense the abdominal walls.
TF, *tensor femoris*, that makes tense the connective tissue of thigh and moves the thigh outwards.
S, *sartorius*, flexes the leg.
AD, adductor group of thigh muscles.
RF, *rectus femoris*, one of the group of extensor muscles of thigh.
TA, *tibialis anticus*, moves foot forwards.
ET, extensors of the toes.

CHAPTER IV.

MUSCLES.—FAT.

46. Uses of Muscles. — The muscles, about four hundred in number, are essentially *organs of motion.* They are of a deep red color,[1] and constitute what is ordinarily called flesh, or, in animals, lean meat. By means of muscles the varied and wonderful movements of the body are performed, and speech is rendered possible. Through their action, the heart pulsates, the blood circulates, and respiration, digestion, and other vital processes are carried on. They also shield blood-vessels, lymphatics, and nerves, assist in diminishing the force of shocks and blows, and give roundness to the figure. They help to hold the bones together and to form the walls which inclose the cavities of the thorax, abdomen, and pelvis.

47. Classification of Muscles. — Certain muscles are grouped about the bones, to which most of them are attached. These are known as *voluntary muscles*,[2] because their movements are, for the most part, governed by the will. Other muscles, which are within the body and form a large part of the walls of hollow organs, as the stomach, intestines, and blood-vessels, are called *involuntary muscles*,

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[1] Muscles but little used, as in young children and in paralyzed persons, have a pale color. In most of the vertebrate animals the flesh is red. In some birds and many fishes it is colorless, yellowish, or pink.

[2] Also as muscles of animal life. Those attached to the skeleton are *skeletal muscles;* also called muscles of organic life.

because they act independently of the will.[1] For instance, the simple presence of food in the stomach is sufficient to excite that muscular organ into its normal and involuntary activity. Certain muscles, as those of breathing, are called *mixed muscles*, "as they belong partly to the voluntary and partly to the involuntary classes. Ordinarily we breathe without exertion of the will, but to a certain extent it is in our power to increase or suspend the process."

48. Connections of Muscles.—Voluntary muscles are connected with bones, and also with cartilages, ligaments, skin, and other structures, either by muscular tissue, or by means of white, firm but flexible, glistening masses of fibrous tissue, known as *tendons*, or sinews.[2] Tendons are inelastic, and serve as connecting bands or cords to hold muscles in position[3] and to enable their fleshy or active portions to move parts of the body that are remote, without interfering with the symmetry and beauty of its outline.[4] How bulky and ill-proportioned, for example,

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[1] Sometimes voluntary muscles cannot be controlled by the will. For instance, twitching of the eyelids may not be readily stopped, and the drunkard cannot always prevent tremors of the hands.

[2] The more fixed or central attachment of a muscle is its *origin*. The movable point to which the force of the muscle is directed is its *insertion*. But many muscles may be made to act from either extremity. In the muscles of the face, one end is attached to bone, the other to movable skin.

[3] "In childhood the fleshy portions of muscles are relatively long and the tendons short. As we grow older, the tendons are relatively longer, and the active fleshy portions less in amount. Hence, to excel in athletic sports, it is needful to begin practising early in life. A baby can readily put its feet in its mouth, or when sitting on a bed with the legs at right angles with the body, can easily lift the legs to an acute angle with the trunk,—a feat that is impossible with an adult."

[4] The tendon of one of the muscles that move the eye passes through a loop or pulley. A tendon under the jaw passes through a slit in the

would be the wrists and ankles, and how clumsy their movements, if the muscular tissue were extended through those parts (*a*). The largest and strongest tendon in the

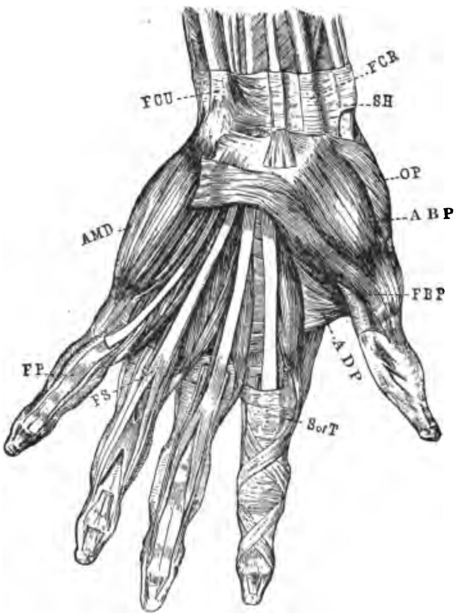

Fig. 25.

Muscles of Left Hand. *Front surface.*

FCU, flexor of ulnar side of the wrist.
FCR, flexor of radial side of wrist.
SH, sheath of connective tissue through which the tendons pass.
OP, the opposing muscle of thumb.
ABP, muscle that draws the thumb outward.
FBP, the short flexor of the thumb.
ADP, adductor that draws the thumb inwards.
S of T, sheath of tendon in position, removed from other fingers to show the arrangement of tendons.
FS, long, superficial flexor of the fingers.
FP, the long, deep flexor of the fingers.
AMD, muscle that pulls the little finger outward.

tendon of another muscle whose direction is different. Tendons may be readily felt at the wrist, ankle, the bend of the elbow, and under the knee, when the muscles are tense.

body is the *Tendo Achillis*, which connects certain muscles on the back of the leg with the heel.[1]

Involuntary muscles, for the most part, are not attached to bones, but to other structures.

49. Arrangement of Muscles.—Muscles vary in shape, and are arranged usually in layers or groups, occupying always the best position to facilitate their own action and to preserve the compactness, usefulness, and beauty of the parts. Those of the face are, for the most part, short and narrow; of the cranium, thin and flat; of the thorax, abdomen, and pelvis, broad and flattened; and of the neck and extremities, long and rounded. Some muscles have a tendon at one end, or at both ends, or at one side, or running through the middle. Others have two tendons at one end, as the two-headed or *biceps* muscle of the front of the upper part of the arm; or three tendons, as the *triceps*, at the back and upper part of the arm. The abdominal cavity is walled in, in front and on the sides, by three layers of strong, flat muscles, their respective fibres crossing the abdomen in different directions, but all centering in a strong tendinous band in the middle line, called the *linea alba*. This strong wall is strengthened still further, in front, by two overlying straight muscles, extending one on either side of the linea alba, from the pelvis nearly to the breast bone.

50. Action of Groups of Muscles.—The respective groups of muscles are named according to the kind of motion produced, their position, uses, etc.[2] Muscles that bend

[1] Tendon of Achilles, so called from the Grecian fiction that this tendon was the only vulnerable portion of the body of Achilles.

[2] The names of muscles have come down to us from the ancients. Their length is often in inverse proportion to the size of the muscle named.

the joints are called *flexors*,—as, for example, those on the front of the arm that bend the forearm, and on the back of the thigh that bend the leg. Those which restore the bent parts to a straight condition are *extensors*. The extensors, corresponding to the above-mentioned flexors, are located, as the necessity of the case demands, on the back of the arm and on the front of the thigh. *Rotator* muscles are those which turn upon their axes the parts to which they are attached. Such are the oblique muscles of the eye and those attached to the radial bone of the forearm. It is by means of the latter that the forearm and hand can be turned around so as to present either side at pleasure.

Adductors are muscles which move parts toward the axis of the body, and *abductors* those which move parts from the axis of the body. Of the first, the large muscles of the chest and back, which draw the arm to the side, and those which draw the lower extremities together, are examples; of the latter may be named the muscles of the shoulder and the outer muscles of the thigh.

Sphincters are annular, or ring, muscles which close or constrict certain natural openings of the body, as the eye and mouth.

51. Muscles, such as the flexors and extensors, the abductors and adductors, which produce by their action entirely opposite movements, are called opposing or antago-

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For instance, a very short muscle which extends from one corner of the upper lip to the nostril upon the same side of the face, whose function is merely to raise the lip, as in sneering, is called the *levator labii superioris alaeque nasi;* while a very long and important muscle of the thigh is more plainly named the *sartorius*, *i.e.* the "tailor," because it is the principal muscle by which that useful functionary assumes his familiar position for work.

nistic. The result of the combined action of opposing muscles, when excessive, is rigidity. It is the easy combined action of the opposing muscles which enables us to stand, or to apply a force properly graduated to the necessities of the most delicate muscular work (*a*). The action of opposing muscles, when healthy, is nicely adjusted, so as not to interfere with their mutually free and easy movements.[1] Their abnormal action is exemplified in the rigidity which takes place in convulsions, and in "lead palsy," where the unchecked contraction of the flexors of the forearm, through paralysis of its extensors, produces a falling of the hand known as "wrist drop."

52. Muscles of Expression. — Ordinarily we show how we feel by our features, and by the position and movements of the body. The expression of the emotions is effected mainly, however, by the varied movements of the facial muscles, especially those which move the lips, eyelids, eyebrows, and lower jaw.[2] Hence these muscles are spoken of as the muscles of expression.[3] The development of certain of them by frequent use produces the jovial, smiling, or laughing face; while development of other groups produces the sad, sour, or disagreeable face.

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[1] The easy picking up of a lead pencil from a table, for example, requires the combined harmonious action of opposing muscles of the shoulder, arm, forearm, and hand, as well as those of the eyes. This harmony of movement is sometimes spoken of as consensus of action. The want of it is apparent in a person having St. Vitus's dance.

[2] Some persons can move the ears by means of developed fan-shaped muscles attached to these organs, which in most persons are rudimentary.

[3] There are 70 pairs of muscles in the neck and face. It has been estimated that the body is capable of 5000 different movements, and the face of 750 different expressions.

53. Structure of Muscles. — A voluntary muscle is composed of bundles of striated or striped fibres called *fasciculi.* The muscular tissue is enveloped in a delicate elastic sheath of connective tissue, the *perimysium*,[1] which

Fig. 26.
Muscles of Expression.

also slips in between the fasciculi and incloses them. The fibres of a muscle generally run parallel to one another throughout its length, converging toward its tendinous attachment. Each fibre consists of a soft, contractile

[1] "Around a muscle."

substance, and is inclosed by a thin, elastic, transparent sheath, the *sarcolemma*.

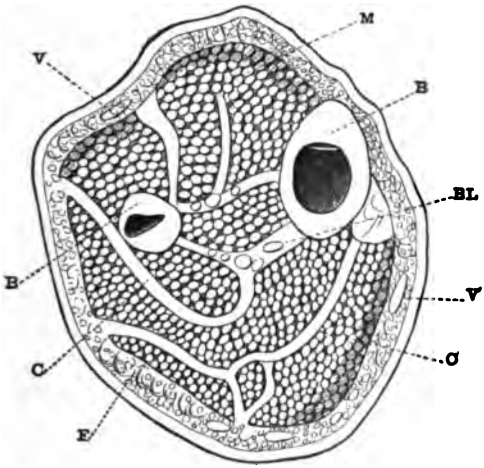

Fig. 27.
Transverse Section of a Leg.

B, bone. F, fat (adipose tissue). M, muscles.
C, connective tissue. V, veins. BL, blood-vessels (arteries and veins).

Involuntary muscles are composed of plain, smooth fibres, not striped, which contain nuclei and nucleoli. These fibres are contractile, spindle-shaped cells, which are held together in bundles by a cement-like substance. These bundles compose larger bundles or flattened bands, which are held together by connective tissue, and frequently interlace.

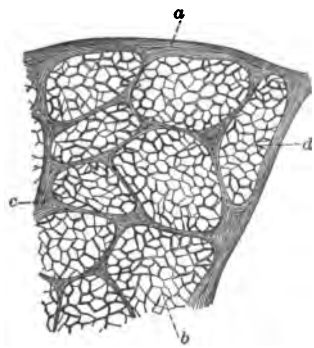

Fig. 28.
Section of Muscle (magnified 50 diameters).

a, perimysium. *c*, connective tissue.
b, fasciculus. *d*, fibre.

Nerves, blood-vessels, and lymph vessels run between and into muscles to stimulate them to activity, to afford

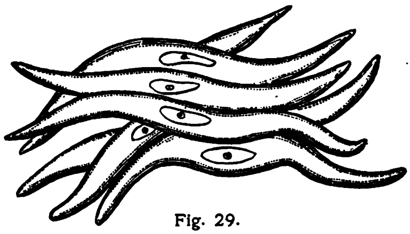

Fig. 29.

Non-striated Fibres of Involuntary Muscles, somewhat separated from each other for microscopic examination.

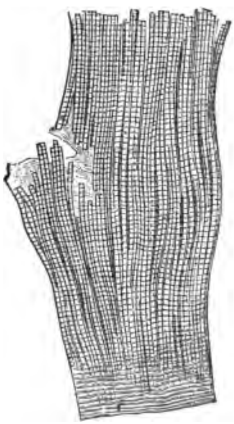

Fig. 30.

A Portion of a Voluntary Fibre, showing the fibrillae, transverse striae, and the sarcolemma detached at one point. Magnified 250 diameters.

nourishment, and to carry away dead material.[1] Fat cells are frequently found among muscular fibres.

54. Under the microscope the fibres of a voluntary muscle are found to be marked with alternate transverse bands, or *striae*, with faint stripes running lengthwise over each fibre.[2] After death, when the muscles are stiffened, or if a muscle is hardened in alcohol, the fibres can be broken up longitudinally into very fine threads, called *fibrillae* (little fibres).

55. Chemical Composition of Muscles. — Muscle consists of about

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[1] Muscles, fasciculi, fibres, connective tissue, nerves, and blood-vessels can be studied in the leg of a sheep.

[2] The transverse stripes are by some believed to be the boundary lines of muscle cells.

three-fourths water, which affords softness and flexibility,[1] the remaining one-fourth being made up of common salt, calcium phosphate, and albuminous substances, the chief of which is *myosin*.[2] Myosin coagulates soon after death, causing rigidity of the body.

56. Properties of Muscular Tissue.—The characteristic property of muscles is *contractility*. The power of shortening and thickening their bulk when tense, or in a state of action, and of becoming elongated and thinner when relaxed, or in a state of rest, is peculiar to muscle fibres, and is sometimes spoken of as muscular irritability. Contractility is normally excited in voluntary muscles by the will acting through the nervous system, but it can also be called into action independently of the will, by various kinds of stimulation, such as pinching, pricking with a needle, the application of an acid or electricity. In involuntary muscles, it ordinarily results from nervous stimulus. Contractions may be extremely gentle, as when the muscles of the eye or hand are engaged in delicate work; or they may be powerful, as in athletic sports or in heavy lifting. Prolonged use, the want of use, a supply of poor or insufficient blood, and certain poisons lessen the normal irritability of muscles. Muscles are also elastic, and are said to have tone when they promptly and in a normal manner respond to stimuli. When repeated stimulation is applied to muscles, they contract in wave-like impulses. "When stimulation of muscular fibres is too rapid, the

[1] Muscles sometimes lose pliability and act with difficulty, when the fluids of the body are diminished by overwork or as the result of disease. Sometimes the motion of tendons, through grooves or canals of bone or cartilage, may produce creaking sounds.

[2] The translucent, jelly-like substance of muscular fibres is sometimes called *muscle-plasma*.

muscle contracts firmly, the wave movement disappears, and the contraction may not be followed by any relaxation for a considerable time, as in muscular cramps, and the disease known as *tetanus*."[1]

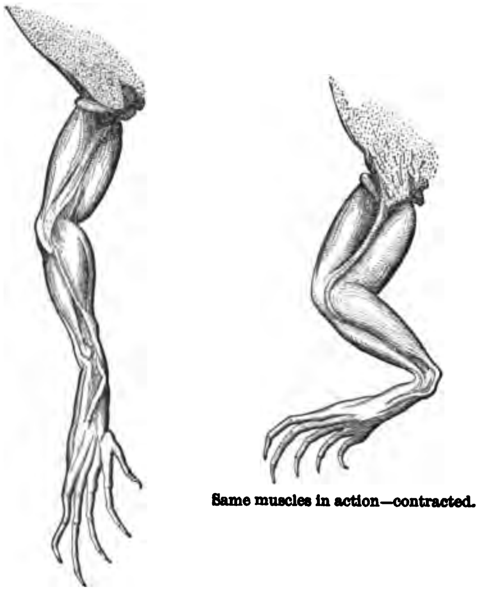

Fig. 31.
Contraction and Relaxation of Muscles.

57. Hygiene of Muscles. — For healthy growth and development muscles require a constant supply of good blood, sufficient nerve stimulus, and alternate exercise and rest. Without these requisites waste products accumulate and

[1] "The skeletal muscles of some insects can contract 1,000,000 times an hour, requiring 300 stimuli per second for complete and continued contraction. In birds, 100 stimuli per second are required; and in man, 40."

inuscular activity is diminished. Overworked muscles waste away equally with idle muscles; in the latter case, useless fat may take the place of the muscular fibres.[1] In the arrangement of nature, certain muscles are intended to be at rest while others are in activity. Even the fibres of a single muscle do not all act at the same time. This provision does not dispense, however, with the necessity for additional rest in sleep.

58. **Sleep.**—All parts of the body, the brain included, require rest, and share, directly or indirectly, in the benefits of sleep. Particularly refreshing is the first sleep, and that which is least disturbed by uneasy dreams, mental effort, and anxiety. Generally, the more both mind and body can be withdrawn from all outside influences, the better. The amount of sleep needed by different persons varies according to the age and condition of individuals. The greater part of infancy is generally passed in slumber; and in old age, also, much sleep is required. In middle life, usually about eight hours a day is necessary, though it is reported of Frederick the Great and Napoleon that they slept but three or four hours out of the twenty-four (*a*). Needed restoration may often be found in a *change of employment*, whether of work or amusement, as well as in sleep. In such cases, if amusement be needed, it becomes as much one's duty to play as it was before to work.

59. **Fat.**—This substance usually constitutes about one-twentieth part of the weight of the entire body. It is

[1] The wasting of muscles from non-use is shown in a broken arm which has been kept in splints for several weeks, or in a sound leg that has been idle for a long time, on account of the other leg's being disabled by injury or disease.

found in all parts of the body, with the exception of the bones, teeth, and fibrous tissues, either in masses or in the form of an emulsion,[1] or in that of globules and granules of oil. In the first form it is called *adipose tissue*, the most familiar example of which is that which is embedded in the areolar or connective tissue, between the skin and the muscles. Animal fat is generally a mixture of three

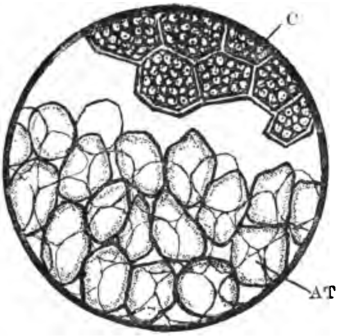

Fig. 32.

(Microscopic view.)

AT, adipose tissue.
C, fat in cells of cocoanut.

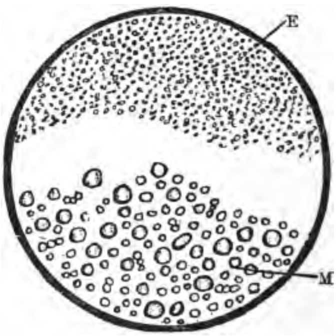

Fig. 33.

(Microscopic view.)

M, fat globules in milk.
E, fat globules in an emulsion.

varieties of fat,—stearin, palmitin, and olein. Stearin and palmitin are more or less solid, as usually seen in the meat of animals; but in the live body, at its ordinary temperature, they are held in solution by the olein with which they are associated.

By the arrangement of the fat about the internal organs, between the muscles, under the skin, and about the joints, it acts as cushions to these structures, maintains their temperature, fills up inequalities in and about the various struc-

[1] That is, in suspension, as in milk.

tures, and greatly enhances the beauty and symmetry of the human form. It also serves for nutrition in timo of need, as is particularly to be observed in torpid animals[1] and in emaciating diseases. In fact, fat being composed of carbon, hydrogen, and oxygen, contains elements which are essential to the nutrition and growth of tissues, and is found in quantity whenever cell growth is rapid, especially in the case of healthy young children.

60. The amount of fat in different persons depends upon age, race, and hereditary tendency; also upon the weather, climate, and occupation; yet there is probably a normal limit as to the amount of fat in the case of each individual. Any amount beyond this limit is likely to be not only inconvenient, but distressing and even dangerous to life, either by impeding the action of the heart or by taking the place of important tissues, thereby producing a diseased condition, which is known as fatty infiltration. Ordinarily, a steady gain of fat within the normal limit indicates an improving condition of the blood and better nutrition, while a deficiency is often the first note of alarm to warn us of the approach of consumption, scrofula, or some other serious disease which has begun its stealthy march in a faulty nutrition.[2] Rapid loss of fat usually indicates impoverishment of the blood.[3]

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[1] The common tortoise, for instance, burrows in the earth in the latter part of autumn, and does not reappear till spring has well advanced. Some species of bears become very fat toward the winter time, and then, during the winter, while hibernating, eat no food, so far as is known. In the spring they come out of their hiding-places, lean and hungry.

[2] It has been observed that cooks, butchers, oilers, etc., are generally exempt from such affections, and it is believed by some authorities that the exemption is dre to the fat absorbed by their skins from the materials which they handle.

[3] In such instances, the fat that remains seems thin and watery.

"Fatty tissue is the most fluctuating in bulk of all the tissues of the body," for within a very short time a large amount may appear or disappear. Its increase is promoted by many of the animal and vegetable substances used as food, and it is the result also of chemical changes that occur within the body, in such food as starch and sugar. It is often injuriously increased by impoverished blood during sickness or idleness, by a continued use of alcoholic drinks (especially ale, beer, and porter), and by fatty, sugary, and starchy foods. It may, therefore, be diminished sometimes by a partial or complete omission of the articles of food and drink mentioned above, by proper bathing and attention to the excretory organs, and by systematic, well-adapted exercise. It can seldom, however, with safety, be kept below the individual's normal standard for a great length of time. The use of drugs or medicines as anti-fat remedies is not always safe, nor is it usually efficacious.

QUESTIONS.

1. Describe muscles.
2. What is their chief use?
3. What two grand divisions of muscles are there?
4. How are muscles attached to the parts to be moved?
5. Why are tendons used for this purpose?
6. Why are the voluntary muscles more often attached to bones than the involuntary?
7. Why do blood-vessels and nerves accompany muscles?
8. What is the chief constituent of muscle substance?
9. What other uses have muscles besides being organs of motion?
10. To what is the moving power of muscles due?
11. How may the contractility of muscles be excited?
12. How may their irritability become weakened?
13. What are opposing or antagonistic muscles? Give examples.

14. What are the respective results of their normal and abnormal action?
15. Name other kinds of muscles.
16. What are the muscles of expression?
17. What is necessary for muscles to be healthy and well developed?
18. When is sleep most beneficial?
19. What periods of life require most sleep?
20. How may muscles be refreshed without cessation of activity?
21. What are the varieties of fat?
22. What are its uses?
23. How does excessive fat become dangerous?
24. How may fat be increased? how diminished?
25. What about the use of drugs to that end?

CHAPTER V.

MUSCULAR EXERCISE.

61. **Physical Culture** has engaged the attention of mankind, in a varying degree, from the very earliest times. Its object, at first, was to strengthen man for defence against his fellow-men and wild animals. At a later date, in the Grecian games, athletic contests were eagerly entered into in a spirit of emulation, and for the cultivation and exhibition of strength and beauty. Among the Spartans, the women, as well as the men, had their physical training. And yet we are told by the medical writers of those times that the excessive exercise indulged in by many of the athletes rendered them "dull, sluggish, and torpid, and that they averaged only five years of (athletic) life." Still later, in the gymnasia, or schools, of the Greeks, efforts were first made to combine physical and mental education, so as to produce "a sound mind in a sound body." Yet, even at the present time, the true value of proper muscular exercise in restoring health, as well as in maintaining it, is not fully appreciated.

62. **Effects of Exercise.** — Exercise, besides developing and strengthening the muscles, causes a muscular pressure upon the blood-vessels, and increases the force and rapidity of the circulation. In this way it promotes the consumption of oxygen by the tissues, and the elimination from them of carbon dioxide and other waste products. Through exercise the breathing power is developed, the

appetite improved, digestion made stronger, the accumulation of fat diminished, and animal heat increased. The nervous system also shares in the general improvement, and, as a consequence, better mental work is made possible.[1] In those colleges and schools where physical culture receives attention, the mental as well as the physical strength of the students has been found to be improved (*a*).

63. Well-balanced Exercise. — In all cases, there should be, as much as possible, a corresponding development of the whole man.[2] Engravers, telegraph and sewing-machine operators, tailors, shoemakers, and all persons who, in plying their vocation, use one set of muscles mainly, are liable to paralysis of those muscles (*a*). Such persons should each day engage for a time in exercises that will call into action the other muscles of the body. In like

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[1] At the Elmira Reformatory twelve of the dullest boys for six months averaged only 45 per cent in their studies. After a course in physical culture, their treatment in every other respect being the same, they reached an average of 74 per cent. Dr. Wey, the physician in charge, says: "With physical culture and improvement there came a mental awakening, a cerebral activity never before manifested in their prison life. Their faces parted with the dull and stolid look they had in the beginning, assuming a more intelligent expression, while the eye gained a brightness and clearness that before was conspicuous by its absence."

[2] Large persons with powerful muscles, but with little endurance, are not able to accomplish so much as wiry small ones, whose powers of endurance have been developed by gradual training. "A man of good physical capacity may be trained so that the voluntary muscles of his arms and chest will be powerfully developed, with a contractile force proportionate to their size, and yet his respiratory power may be so disproportionate that he cannot run a hundred yards without gasping; and another, or the same individual, if possessing ordinary locomotive capacity and fair development, may be trained to run ten times the distance without distress, while the voluntary muscles of his arms and chest remain as they stood at the time that the training began." — McLaren, *Training in Theory and Practice.*

manner those whose callings lead them to the exercise of their brains only, to the neglect of their muscles, make too large a demand upon the nervous system, and pay the penalty in disorders of that system.

64. **The Powers of Endurance** of individuals are very unequal. Accordingly, what would be proper exercise for one person may be very improper for another. Some feeble persons are too ambitious and need restraint, as much as the lazy need urging. Exercise that is beyond the strength of the individual or of a kind to which he is unaccustomed, or attended by severe or sudden strains on undeveloped muscles, will be followed by bad results,— for example, by exhaustion, cramps, loss of appetite, overstrained heart, and even diseases of the blood-vessels and nervous system (*a*). The hard work necessitated by certain occupations of life often produces serious results, even in very strong and well-developed men. It is especially important that such occupations should be carried on in the open air, or in well-ventilated rooms, and that the workers should have the proper kind and amount of food. Attention to these details would undoubtedly save many lives.

65. **Proper Muscular Exercise** is that which is adapted to the age, health, and strength of the individual. It should be varied and agreeable in character, and pursued daily, either in the open air or in well-ventilated places, but never to the point of weariness.[1] Exercise — walking, for example — which is systematically undertaken merely for the sake of exercise is not only irksome and likely to

[1] The custom of years prescribes certain seasons for out-door games and pastimes. Unfortunately, people do not always observe them, but cling tenaciously to certain sports which they prefer.

be given up after a time, but is not so beneficial as when it is associated with an agreeable visit, beautiful scenery, the gathering of flowers and shells, or even the purchase of some desired object.[1]

66. Young children, even babies, should not be carried more than is absolutely necessary. They will exercise themselves sufficiently if placed in warm but well-ventilated rooms, where the limbs can have free movements, unimpeded by tight or heavy clothing. Childhood, indeed, is a period of restless activity, and by the time a child is three years old *systematic exercise* becomes necessary. Gentle walks, running after and throwing balls, playing with clean sand, and the like, should be regularly permitted and encouraged. Much harm is caused by confining young children and putting barriers around their natural desires for play. In the case of older children and youth, no system of artificial exercise can take the place of that afforded by the usual out-door games, such as base-ball, foot-ball, leap-frog, hoop rolling, or hare and hounds, always provided they are not played too roughly or continued too long. These sports may be pursued advantageously, as a rule, up to forty or forty-five years of age. At about this age natural degenerative changes occur in the body, and care is particularly necessary that the heart

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[1] "I have heard that that benevolent nobleman, Lord Rosse, during the famine years, anxious to relieve distress, and equally anxious not to encourage habits of pauperism, paid men so much a day for digging holes in his demesne, and paid them again for the filling of them up. The laborers are said to have manifested the most extreme disgust at the occupation, although the work was not harder than most useful labors. It is this sense of the inutility of the work done by the labor in some of the military prisons which constitutes much of the severity of the punishment. And this remark is as true of mental exercise as of bodily." — MAPOTHER, *Lectures on Public Health.*

and blood-vessels be not overstrained. Hunting (if moderate) and fishing are more suitable to this period of life. At sixty and upwards exercise continues necessary; but the tissues having become still weaker, it should be very gentle in character.

67. There is no physiological reason why girls, instead of being limited to a round of spiritless games which are of very little use in developing strength, quickness of motion, or the power of endurance, should not engage in many of those sports which are the delight of boys (*a*). The opportunities of out-door exercise for girls and women are, unfortunately, not so many or so diversified as for boys and men. Sedentary habits are especially the bane of women in prosperous circumstances (*b*).

68. **Best Times for Exercise.** — The early part of the day — not immediately on rising, however, but after the system has been toned up by some slight food and preliminary gentle movements — is the best time for hard work or exercise; for then the body has had the benefit of the rest of the previous night. It is not safe to exercise violently soon after a hearty meal, or when the stomach is empty, or when the body is in a state of exhaustion. At one time it was commonly believed that a long walk before breakfast was especially desirable, but the bad results following this exercise in many instances, such as exhaustion, faintness, dyspeptic and nervous disorders, have served to dispel the idea among careful observers. The gentle nervous stimulus given to the whole system by a little light food in the stomach after its long fast is needed by most people, and would be beneficial to all, before exercising in the early morning.

69. Varieties of Exercise. — The different forms of exercise may be classified as follows: 1. Those that bring into nearly equal action *all* the muscles of the body, as swimming, horseback riding, fencing, boxing, base ball, foot ball, lawn tennis, and military drill. 2. Those that exert the muscles of the *upper* part of the body principally, as bowling and shooting. 3. Those that serve to develop principally the muscles of the *lower* part of the body, as walking, dancing, skating, and bicycle riding.[1]

Most of these exercises are beneficial to both sexes. Certainly every one should learn to swim. Apart from its utility as a safeguard to life, it is the experience of one of the large swimming schools in London that carefully regulated swimming develops muscle, and relieves to a great extent backache, or pain in the lumbar muscles. Horseback riding also is a valuable form of exercise. As Dr. Holmes expresses it, "Saddle-leather is in some respects even preferable to sole-leather; the principal objection to it is of a financial character." No exercise, however good, should be overdone (*a*).

70. Gymnasiums. — A gymnasium is valuable for those persons who do not have opportunities for out-of-door exercise, or who need the stimulus of class instruction and the companionship of fellow-workers, accompanied with systematic drill. But too often competition is carried so far that the weak are injured. To effect the most good, the gymnasium should have a medical superintendent, in order that pupils may not be taxed beyond their strength; that the exercise may be adapted to the

[1] Notwithstanding the fact that *long distance* bicycle riding is quite common, it should be thoroughly understood that for persons with weak heart, lungs, blood-vessels, or kidneys, such riding is dangerous.

individual; that proper ventilation may be maintained, and other hygienic rules observed; and that assistance may be given promptly in case of accidents. For persons who cannot leave their houses, various appliances, such as dumb-bells, Indian clubs, rowing machines, and rubber bands or cords are beneficial.

71. Passive Exercise. — Persons too feeble to use their own muscles in exercise will obtain benefit from carriage riding, the use of electricity, or the gentle daily rubbing, pressing, and moving of their muscles by another. This last procedure is known as *massage*, and is every day becoming more popular with invalids. Where the will is but slightly exerted, as in the above examples, the exercises are known as *passive*.

72. Effects of Alcohol and Narcotics upon Muscles. — The tremulousness of muscles and their inability to effect any complicated movement, so frequently observed in persons under the influence of alcohol, is largely due to the disturbing effects of the drug upon the nervous system. However, it is true that muscles are sometimes impaired, *i.e.* lose tone and become flabby, as the result of impaired nutrition brought about by alcohol in the blood. When so weakened, they are in no condition to respond promptly to normal nervous impulses or stimuli. The result is that both voluntary and involuntary muscular movements are sluggish. Experience has shown that alcoholics can seldom be relied upon to sustain either nervous energy or muscular strength. As Professor Stewart says, "In severe and continuous exertion, with exposure to all weather, as in war and exploring expeditions, alcohol is injurious; and it must be avoided in mountain climbing."

"The British authorities some time ago made a test of

the alleged value of alcohol when men are subjected to unusual and exhausting labor. Experiments were made at different times and under varying conditions, with three regiments from each of several brigades. In one, every man was forbidden to drink any alcohol whatever while the test lasted; in the second, malt liquor only was taken; in the third, a ration of whiskey was given to each man. The whiskey drinkers manifested more dash at first, but generally in about four days showed signs of weakness and fatigue; those given malt liquor displayed less dash at first, but their endurance lasted somewhat longer; while the abstainers improved daily in alertness and staying powers."

73. *Tobacco* has the power to induce through the nervous system a feeling of lassitude, which results in inefficient use of the muscles, and consequent weakening.

Opium, *chloral*, and other similar drugs, used repeatedly or in large amount, produce even more depressing effects.

QUESTIONS.

1. What have been the motives for physical culture in the past, and by what bad effects was excessive exercise said to have been followed?
2. What is proper exercise, and what are its effects?
3. How does it affect the mental health, and why?
4. What is improper exercise, and what are its effects?
5. What is to be said of exercise at different ages?
6. What of the exercise of women and girls?
7. What of exercise in the early morning?
8. What of the varieties of exercise?
9. What of the gymnasium?
10. What is *massage*, and when is it to be employed?
11. How do alcohol, tobacco, opium, etc., affect muscles and interfere with muscular exercise?

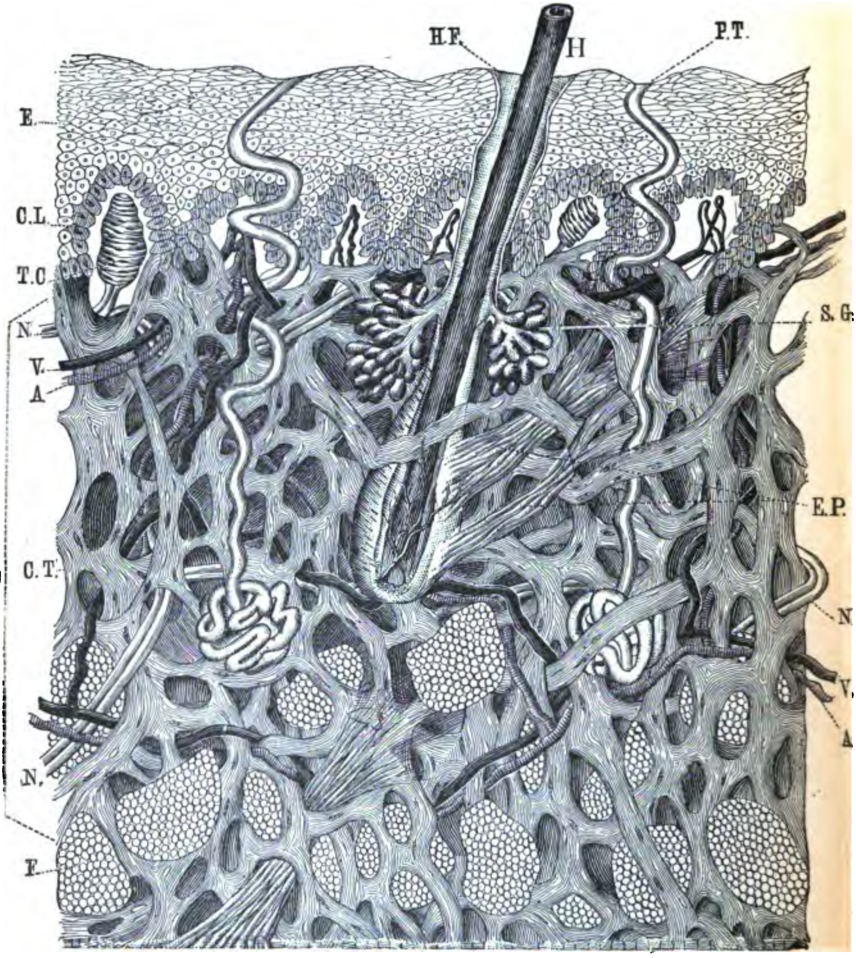

Fig. 34.

Longitudinal Section of Skin (partly diagrammatic), magnified about 100 diameters. Its structure and contents (with the exception of the lymphatics).

E, epidermis.
D, dermis.
CL, color layer.
TC, tactile corpuscle.
N, nerve.
V, vein.
A, artery.
CT, connective tissue.
F, adipose tissue.
HF, hair follicle.
PT, perspiratory tube and gland.
SG, sebaceous gland.
EP, erector pilae muscle.
H, a hair.

CHAPTER VI.

THE SKIN AND KIDNEYS.

I. THE SKIN.

74. The Skin, or external covering of the body, is strong, flexible, and elastic, varies in smoothness and delicacy in different parts of the body, and has no less than six functions.[1] It has been likened to a sentinel whose duty is to guard the body against attacks, both from within and from without. It consists of two distinct layers, — an inner, the *dermis* or true skin, and an outer, the *epidermis* or cuticle.[2]

75. The Dermis is composed of a dense network of fibrous and elastic connective tissue (*a*), in the meshes of which are blood-vessels, lymphatics, nerves, sebaceous glands, sweat glands, hair, hair follicles,[3] and muscular fibres attached to some of the hair follicles.[4] Underlying the dermis, and closely blended with it, is the subcutaneous connective (*areolar*) tissue, inclosing vessels, nerves, adipose tissue,[5] sweat glands, and sometimes muscular fibres.[6]

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[1] See Section 84.

[2] Called also scarf skin and false skin.

[3] Little bags, or pouches.

[4] Through the meshes of the connective tissue oozes nutritious watery material from the blood-vessels. In dropsy, this material distends the connective tissue.

[5] The wrinkling of the skin of old persons is due to a diminution in the amount of fat, as well as to a lessened elasticity of the connective tissue.

[6] Muscular fibres are abundant in the skins of many animals, enabling them to shake off insects by a wrinkling motion of the hide.

The surface of the dermis, upon which the epidermis is moulded, rises into minute eminences called *papillae*, which are arranged in groups or rows, producing ridges and furrows.[1] They are most numerous in the most sensitive parts, such as the tips of the fingers, where they number about thirty-five thousand to the square inch. The papillae are made up of connective tissue, terminal blood-vessels arranged in loops, nerves in fine threads, and oval enlargements known as tactile corpuscles, or little bodies with touch-power, in which the sense of touch resides.[2]

The extreme sensitiveness of the papillary portion of the skin is made apparent whenever the raised cuticle covering a blister is broken and anything, even air, comes in direct contact with the true skin.

76. The Epidermis is composed entirely of cells, rounded and soft at its lower portion, flattened, hard, and horn-like upon its surface, where they are exposed to the atmosphere and to external sources of injury. Owing to attrition and chemical action, the outer cells of the epidermis are constantly being removed, while the deeper ones, formed from the dermis, are pushed forward to take their place, growing harder and flatter as they approach

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[1] These ridges and furrows may be distinguished by means of a good magnifying glass. Their arrangement upon the fingers of different persons assumes different patterns. This fact is made use of sometimes in the detection of criminals.

[2] In the outer portion of the dermis, and below the papillae, other nerves end in enlargements, but these are known as Paccinian corpuscles. The nerves of the skin are sometimes classified as follows: (1) nerves of *sensation;* (2) *trophic* nerves, or those which control the nourishment of the skin; (3) *secretory* nerves, or those that control the action of the glands; and (4) *vasa motor* nerves, or those which regulate the action of the blood-vessels.

the surface.[1] Having no nerves except a few in the lower portion, the epidermis is not sensitive, and being without blood-vessels, it cannot bleed. It is well adapted, therefore, to cover and protect the sensitive tissues beneath. It thickens in the various parts of the body that are most used, as on the palms of the hands, the soles of the feet, on the knees of the shoemaker, or on the breast of the burnisher of books (*a*).

77. The Color of the Skin is due in part to the blood circulating through it, and in part to the pigment or coloring matter of the skin in the lower cells of the epidermis. An unusual quantity of red blood in thin portions of the skin causes it to blush, or redden, while blood tinged by the yellow coloring matter of the bile imparts a jaundiced or yellow color. The distinctive variations in color of individuals, families, and races are due to the diversified arrangement of the pigment. The whiteness of the skin of albinos is due to the absence of this pigment, while freckles, and the peculiar irregular discoloration seen upon the skin of so-called leopard boys, are owing to variations in its quantity, quality, or distribution.

78. Sweat Glands. — Classified as *appendages of the skin* are the sweat glands, the sebaceous glands, the hair, and the nails. Sweat glands are minute tubes,[2] closed at the lower end, and opening upon the free surface of the epidermis. They extend downward through the epidermis

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[1] A microscopic examination of water in which the hands are washed will almost always show an abundance of epidermal cells, even though the water seems quite clear. Contagious diseases sometimes spread from one person to another by means of epidermal cells mingled with disease germs.

[2] About $\frac{1}{370}$ of an inch in diameter and $\frac{1}{15}$ of an inch in length.

into the dermis and subcutaneous areolar tissue, where they end in coils, intertwined with capillary or hair-like blood-vessels. From the blood in these vessels the perspiration is constantly filtered out by the sweat glands. The upper extremity of each coil is the commencement of a perspiratory tube. Their openings, together with the outer openings of the tubes of the sebaceous or oil glands, constitute the pores of the skin.

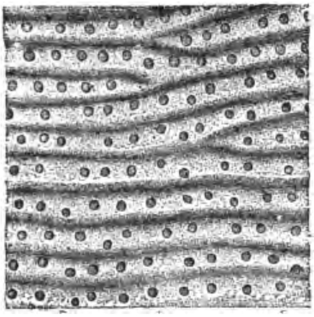

Fig. 35.

Epidermis from the Palm of the Hand (with its pores), as viewed from the under surface. Magnified eight diameters.

Sweat glands are found nearly everywhere in the skin, but are most numerous in the palms, soles, and armpits, where they number from 2685 to 2736 to the square inch. Upon the entire surface of the body there have been estimated to be between two and three millions, and the entire length of the secreting surface is said to be about two and a half miles.[1] The very great number of glands, and the coiled and twisted arrangement by which considerable length is attained in minute spaces, indicate the great importance of the work that they have to perform (*a*).

The function of the perspiratory glands is to eliminate the debris of used-up tissues, and to keep the body comfortable in the varying temperature and conditions to which it is exposed.

79. Perspiration is generally a clear liquid, containing water, sodium chloride, ammonia, urea, carbon dioxide,

[1] They may be considered as flexible living drain pipes or drainage tubes.

and other waste products. The importance of a free flow of perspiration is illustrated by the bad effects resulting from any sudden check of it, as in catching cold and in fever. In such cases extra excretory work is thrown upon other organs, especially upon the lungs and kidneys, and in this way the health is often permanently impaired.

Most of the perspiration which is brought to the surface by the sweat glands is immediately evaporated in the form of an imperceptible vapor, and is therefore termed insensible perspiration, as distinguished from sensible perspiration, or sweat, which is the result of vigorous exercise, over-heat, etc. The constant evaporation of perspiration into the surrounding air is the most powerful of all the means whereby the surplus heat is carried off and the body kept at its normal temperature. In health, whenever the body begins to suffer from excess of heat, as, for example, during violent exercise, the skin responds to the urgency of the occasion, and pours out the due amount of insensible perspiration or of sensible sweat.[1]

80. Under ordinary circumstances the *amount of perspiration* excreted in twenty-four hours is from two to three pounds, but it varies with the temperature, current, and moisture of the air, the depressed or excited state of the nervous system, or the amount of physical exercise taken. Workmen in gas-houses, furnaces, iron-works, and other places where they are subjected to great heat, may perspire as much as three pints in an hour. To prevent exhaustion, such persons drink freely of water, or,

[1] The value of the skin as a regulator of temperature is sometimes strikingly shown when, from catching cold, the body is alternately chilly and hot. A tepid bath taken early in this disordered condition produces a sweat, and the equable normal temperature is regained.

better still, of water containing oatmeal. A hot and dry atmosphere accelerates perspiration, while a moist or muggy one retards it, producing inconvenience and sometimes great suffering. It is related of Chabert, "the fire-king," that, if the air were dry, he could enter, without discomfort, a chamber where the temperature was 400° F., but could not endure a moist atmosphere of a much lower temperature.[1] Perspiration is also impeded by cold and draughts of air.

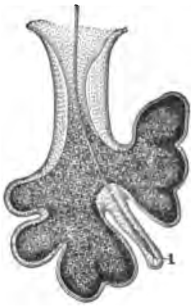

Fig. 36.

Section of Sebaceous Gland having two lobules.

1, rudimentary hair follicle, containing a fine (downy) hair.

81. The Sebaceous Glands secrete an oily matter, which lubricates the skin and hair and thus preserves their softness and pliancy.[2] They are located in the dermis, and are clusters of simple follicles, with tubes connecting with a common or main tube. Most of the main tubes open into the hair sacs (Fig. 34); others open directly upon the surface of the skin, and are especially numerous about the face.

82. Hairs are distributed more or less abundantly over the surface of the body.[3] Their bulbs or root enlarge-

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[1] "A temperature of 100° F. in the dry air of South Africa is quite tolerable, while 85° in the moist atmosphere of Bombay may be oppressive."

[2] In sebaceous glands minute (microscopic) animalculae are sometimes found, but they are not so frequent or so harmful as some sensational publications would lead us to believe. What are often called flesh worms are nothing more than masses of fatty matter tipped by black points, or dirt, which has adhered to them at the mouths of the sebaceous glands.

[3] It has been estimated that a thin head of hair contains 90,000 hairs, while a thick head of hair has 133,920.

ments are inserted in special hair sacs or follicles, or, in the case of the fine downy hairs, in sebaceous follicles. The shafts of the former pass out obliquely through the ducts of the follicles (Fig. 34). Each hair is oval or somewhat flattened, and is composed of a pith-like substance in the centre, surrounded by a fibrous tissue, and this by a so-called cuticle, or layer of epidermis-like cells.[1] The fibrous and pith-like tissues contain a pigment or coloring matter. Hairs are well supplied with blood at the base of the hair follicles, and also, it is believed, with nerves. They are living tissues, strong and elastic.[2]

To the hair follicles are attached muscular fibres (*erector pilae*, Fig. 34), which, under the stimulus of fear, horror, cold, etc., cause the follicles to be more perpendicular, and thus make the hair "stand on end." Hair is subject to various diseases which may shorten its length, change its color, or destroy it. It is affected by the same conditions as the skin, of which it is a part (*a*).

The hair has various uses. That upon the head and face protects from cold and excessive heat, and diminishes the force of blows. The eyebrows prevent the perspiration from running into the eyes; the eyelashes keep out dust; while the hairs at the orifices of the nose and ears protect those parts from dust and insects.

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[1] Under the microscope the sides of a hair seem to be roughened. The hair of certain animals is perceptibly rough to the touch. Human hair may become rough from disease. Very flat hair is apt to curl like a shaving.

[2] It has been found that a hair ten inches long will stretch to thirteen inches; and that a hair stretched one-fifth returned to within one-seventeenth of its original length; also, that a single hair of a boy, 8 years of age, supported a weight of 7812 grains; one of a man of 22 years, 14,285 grains; of 57 years, 22,222 grains.

83. Nails are modifications of the epidermis, identical in formation, but peculiar in appearance and manner of growth. The root of the nail rests in a matrix, which is a fold of the dermis, particularly rich in vascular papillae, from which the nail cells are produced.[1] When nails are destroyed, new ones will be formed if the matrix is uninjured. Nails are a support and a defence to the ends of the fingers and toes, assist in picking up small objects, and, if healthy and in good condition, add comeliness to the parts to which they are attached. The health of the nails is affected by local or general diseases. They may become rough or split or marked by grooves or discolorations, as the result of disease. They should never be bitten off, but carefully trimmed with scissors, a sharp knife, or a nail file, but never to "the quick."[2]

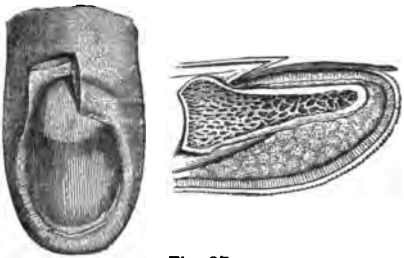

Fig. 37.

Two Views of the End of a Finger. In the first, part of the skin covering the base of the nail is cut and turned back to show the base of the nail. In the second (a perpendicular section), the relations of the nail to the skin, fat, muscle, and bone are shown.

84. The Various Functions of the Skin. — *First.* The skin is a *protective covering.* This quality is due mainly to the hair, the structure of the epidermis, and the strength of

[1] The pink color of a healthy nail is due to the blood beneath. The little white area towards the root of a nail, called *lunula* from its crescent shape, has less blood under it than other parts of the nail.

[2] Dirt under the ends of nails frequently holds disease germs. A ***hang-nail*** is a sliver of skin attached at one end, and should be cut off close to the point of attachment.

the connective tissue. In a good-sized man the skin contains about seventeen square feet of surface, is thick and strong upon those parts most subject to pressure and friction, but thinner where motion or greater elasticity is necessary, as on the eyelids, in the armpits, under the knees, and over the abdominal organs.

Second. It is an *organ of sensation.* Being abundantly supplied with nerves, it enables us to appreciate all degrees and varieties of touch and temperature. The value of this sensitiveness is especially appreciated in the different trades and vocations of life, and most of all when it is diminished or lost. In a palsied limb it may happen that a severe frost-bite, burn, or other injury will even destroy the tissues without the knowledge of the sufferer.

Third. It is an *organ of excretion*, purifying and eliminating from the blood the waste products which the perspiration holds in solution.[1]

Fourth. It is the great *regulator of animal temperature.* Though the general temperature of the human body is about $98\frac{1}{2}°$ F., there is, within the limits of health, a normal variation of about 1° below and above that point. The proper regulation of the temperature depends in part upon the elimination of watery vapor by the lungs, but mainly upon the perspiratory function of the skin.

Fifth. It is an *organ of absorption.* It takes up and passes through it into the lymph and blood vessels certain substances with which it may come in contact. It has been found by experiment that the body absorbs water through the skin (*a*). Certain drugs, as strychnine,

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[1] It is estimated that the skin and lungs in 24 hours excrete five pounds of waste material.

quinine, mercury, and belladonna, produce their usual effects when applied to the tender parts of the skin. Rubbing oily preparations into the skin has long been practised to increase warmth and furnish nourishment. Careless workmen in lead works, painters, and mirror-silverers are often poisoned by lead or mercury absorbed through the skin. The evil effects which sometimes result from using cosmetics and hair dyes are due to the absorption of harmful material. Friction increases the rapidity of absorption.

Sixth. The skin, by virtue of its powers of absorption and excretion, serves as an *accessory organ of breathing.* It absorbs oxygen and gives out carbon dioxide, performing, it is estimated, from one-fortieth to one-fiftieth of the respiratory function.

85. The Relation of the Skin to Other Parts of the Body. — Owing to the extent, structure, and variety of functions of the skin, its condition has much to do with the general health. The skin, lungs, liver, bowels, and kidneys are allies in physiological action. All excrete waste material, each in its own way. If, therefore, from any cause the normal action of one or more of these organs is interfered with, extra and unnatural work is thrown upon the others, and the excessive excretions produce discomfort, and often inflammatory disease of greater or less danger. The skin is also intimately connected with the internal organs by nerves and vessels. Hence, if it be severely injured, as by an extensive burn, these organs may become inflamed and death may result. Conversely, because of the same intimate connection, or "sympathy," as it is sometimes called, indigestion often causes eruptions to appear upon the skin.

86. The Effects of Alcohol and Narcotics upon the Skin. — Alcohol, taken in small quantities, temporarily flushes and gives a feeling of warmth to the skin, by increasing the flow of blood through its minute blood-vessels. By repeated indulgence in its use, the skin of the face becomes puffy and has the blotched appearance so characteristic in the confirmed drunkard. This condition is due partly to a paralysis of the muscles of the blood-vessels, the consequent dilatation of these vessels and a stagnation of blood, and partly to an interference with the circulation of blood in other portions of the body. The congestion of the blood so caused interferes with the nutrition of the skin and the exercise of its functions.

Alcoholics are frequently used under the impression that they afford warmth. Persons relying upon them for this purpose are apt to suffer intensely when exposed to severe cold.[1] That they temporarily furnish a feeling of warmth in the skin is evident, but the increased heat brought to the surface of the body by the increased volume of blood disarranges the heat equilibrium of the body and is soon dispelled by radiation.

As Dr. Brunton[2] puts it: "Alcohol does warm a man in one way: it warms his skin and warms the ends of the nerves in the skin, and thus conveys to his sensorium[3] the feeling of warmth, but at the expense of internal organs, by dilating cutaneous vessels. Arctic observers do not like their men to drink alcoholics. . . . A party

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[1] Dr. Kane, in his *Arctic Explorations*, says: "Coffee in the morning seemed to last the men through a large part of the day, and tea soothed them after a day's labor and exposure. They both operated upon fatigued and overtaxed men like a charm, and their superiority over alcoholic stimulants was very marked."

[2] *Lectures on the Action of Medicines*, 1897.

of engineers were surveying in the Sierra Nevada. They camped at a great height above the sea level, where the air was very cold, and they were miserable. Some of them drank a little whiskey, and felt less uncomfortable; some of them drank a lot of whiskey, and went to bed feeling very jolly and comfortable indeed. But, in the morning, the men who had not taken any whiskey got up all right; those who had taken a little whiskey got up feeling very unhappy; the men who had taken a lot of whiskey did not get up at all,—they were simply frozen to death. They had warmed the surface of the body at the expense of their internal organs."

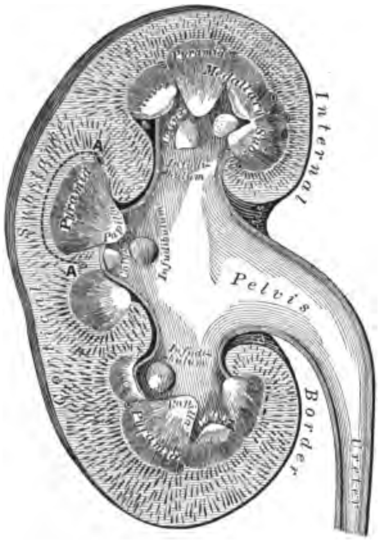

Fig. 38.
Section of Kidney. (Gray.)

87. The habitual use of *tobacco*, and sometimes the occasional use, tends to interfere with the nutrition of the skin, and is apt to make the face pale and unhealthy-looking.

Opium and other narcotic drugs have a similar tendency.

II. THE KIDNEYS.

88. **The Kidneys** are two bean-shaped organs, lying in the back of the abdomen, just under the diaphragm, one

on each side of the vertebral column. They are well supplied with blood-vessels, nerves, and lymphatics, and are composed of two parts, a *cortical* or outer portion, and an inner or *medullary* portion, made up of small tubes separated by connective tissue and arranged in the form of pyramids. These tubes open at the apices of the pyramids into a cavity known as the *pelvis*, which connects with the bladder by means of a long duct, the *ureter*. They are known as uriniferous tubules and are lined by a single layer of secreting cells. The outer end of each tubule terminates in a dilation which contains a knot of capillary blood-vessels.

89. Function of the Kidneys. — The kidneys filter water, salts, and most of the urea from the blood. The urea is the result of a final oxidation of the nitrogenous material of the body, and, if not thrown out of the body, it becomes exceedingly poisonous. This excretion is effected mainly by the *urine*, through the kidneys. The amount of this fluid should be slightly more than the water taken into the body in twenty-four hours.

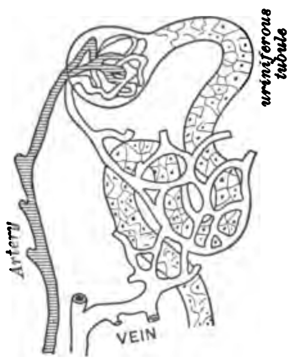

Fig. 39.
Uriniferous Tubule and Dilation.

Severe cold, or any disease or stimulation that impairs the functional activity of the kidneys, tends to an accumulation in the blood of poisonous nitrogenous wastes.

90. Effects of Alcohol upon the Kidneys. — Alcohol excites the kidneys to increased activity, by dilation of

their blood-vessels and irritation of their structural cells. Its repeated use frequently leads to a more or less permanent dilation of the urinary tubules, destruction of the secreting cells, fatty infiltration of the cortical substance, and either contraction or enlargement of the kidneys,—*i.e.* Bright's disease and other diseases of the kidneys.

As to *tobacco*, *opium*, and other narcotics, no special effects on the kidneys are noted.

QUESTIONS.

1. Describe the skin and name its different layers.
2. Locate and describe the dermis.
3. What are the papillae, and what peculiar power resides in them?
4. Where is the subcutaneous tissue, and what does it contain?
5. Where is the epidermis, of what is it composed, and what passes through it? What is its function?
6. To what is the color of the skin owing?
7. What are the appendages of the skin?
8. Describe the sweat glands and their functions.
9. What affects the flow of perspiration, and, if checked, what follows?
10. Describe the sebaceous glands and their uses.
11. Describe the hair and its uses; the nails and their uses.
12. What are the functions of the skin? Describe each.
13. Explain why the skin and other excretory organs are mutually affected by the condition of each other.
14. What connection has the condition of the skin with the general health?
15. How does alcohol interfere with the functions of the skin?
16. Why is it unreliable as a heat producer?
17. Where are the kidneys, how are they arranged, and what is their function?
18. How does the repeated use of alcohol impair their function?

CHAPTER VII.

BATHING.

91. The Value of Bathing. — Though bathing has at all times been considered of value, its full importance as a *sanitary measure* is not even yet generally appreciated. The bathing establishments of the Ancients were many and magnificent, and were patronized by multitudes daily, partly for health, but largely because bathing in them was inexpensive, and the baths were luxuriously appointed. In Eastern countries, bathing has always been a religious rite. From time to time it has been regarded as a diversion by the devotees of fashion. It should be a religious duty, a sanitary measure, and a perpetual fashion.

92. Bathing as a Sanitary Measure. — *First.* It *assists the skin in the discharge of its functions*, and so materially helps to maintain health, beauty, and endurance. It fortifies the body against colds,[1] fevers, certain skin eruptions,[2] and internal disorders. Various skin and contagious diseases

[1] Dr. C. R. Agnew, after twenty-nine years' practice in New York City, wrote: "Inattention to health laws produces defects in tissue building. There is a morbid sensibility of the skin and mucous membranes. I arrive at the causes by the result of treatment, for I find that by proper shoeing, open fires, the cold bath in the morning on rising, followed by brisk rubbing with a pair of English bath-mittens and the use of the strap, and by the exposure of the skin to the air, very many times catarrhs disappear without any local treatment whatever."

[2] It is the testimony of many persons that systematic bathing prevents and cures chafing of the skin much better than powders, ointments, etc.

owe their origin to, and spread most rapidly among, the slovenly in the crowded parts of cities.

Second. It *removes dirt, odors, and poisonous materials.* Perspiration, ordinarily a harmless fluid, if allowed to accumulate upon the skin and mingle with dirt of various kinds, clogs the pores. It may even undergo chemical changes, and become an irritant or produce poisonous matter which may be absorbed into the system.

Third. Skin cleanliness augments the nutritive effects of food.[1] In other words, the assimilation of new materials is promoted by a thorough removal of the old.

93. Proper Bathing is that which is adapted to the age, health, peculiarities, and occupation of the individual. It should be performed in a comfortable atmosphere, and be accompanied by a brisk rubbing of the skin, with the hands, a flesh brush, or mittens made of coarse crash. It should be followed by a thorough drying with a firm, good-sized towel, or, in the case of old and feeble persons, by friction over a loose flannel gown put on the dampened skin.[2] As very young children lose heat rapidly, they should, after a bath, be very promptly but gently rubbed, dried, and warmed.

94. Soap is generally necessary as an adjunct of bathing, to remove greasy particles by its chemical action. It should be made of good animal or vegetable fat, combined with

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[1] The eminent English sanitarian, Mr. Chadwick, said: "It should therefore be preached to the poor, as an additional inducement to skin cleanliness, that the same food which is required to make four children that are kept dirty thrive, will serve to make five thrive whose skins are daily washed and kept clean."

[2] Considerable comfort may be derived from friction (especially of the upper part of the body) with mittens merely dampened, or by dry rubbing with mittens or with the bare hands.

potash or borax, as is castile, cotton-seed oil, olive oil, and palm oil soap. Soaps containing an excess of alkali, or made from poor fats or oils, or containing other impurities, irritate the skin and produce eruptions.[1] If the skin is sensitive or harsh and dry, it may be well to apply a little vaseline or oil, rather than to use soap.

95. **Times for Bathing.** — Though the very strong and healthy may, with impunity, bathe at almost any time, most persons should not take more than a sponge bath before breakfast, as at that time the bodily powers are weakest; nor take a prolonged bath when fatigued, or just before or just after a hearty meal or unusual exercise. About 11 A.M. is a suitable time for most persons. Those who are feeble and catch cold easily can generally bathe more safely just before going to bed. After bathing, they need extra warm bed-clothing, but should not have enough to produce sweating.[2]

96. **Varieties of Baths.** — Ordinary fresh-water baths are classified as hot, warm, tepid, temperate, cool, and cold.[3] The shower bath stimulates the skin by the force of the water, as well as by its temperature. Salt water baths,

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[1] Among the very poor, common laundry soaps are frequently used for toilet purposes. Some of these soaps are injurious. The demand for cheap articles has brought into the market many toilet soaps, too cheap to be always reliable.

[2] At the seaside, only the hardiest should attempt an early morning dip in the surf. Many persons are injured by bathing very soon after a hearty meal of clams or other shell-fish. Such food needs strong digestive powers and ample time for digestion. This process is interfered with by such bathing, and blood is diverted in increased quantity into weak blood-vessels, sometimes causing apoplexy and death.

[3] Hot, 98° to 112° F. Warm, 92° to 98° F. Tepid, 85° to 92° F. Temperate, 75° to 85° F. Cool, 60° to 75° F. Cold, 30° to 60° F.

mineral baths, and others are resorted to either for cleanliness, for their supposed medicinal effects, or as a means of nourishment. Among these are the Russian or vapor bath,[1] the Turkish or hot-air bath,[2] and the cold air, broth, and even mud and blood baths.

Salt-water bathing has much greater tonic effects than bathing in fresh water. At the sea-shore the air, also, contains particles of salt. There, too, are new scenes and surroundings, and the water, dashing with force against the body, gives occasion to vigorous muscular exercise. All this exercise, combined with the stimulating properties of the salt water itself, tends greatly to quicken the circulation, and to add value to the bath. But to obtain all the good effects, the bather should first thoroughly wet the head and shoulders, then dash into the water, move briskly about, and come out before feeling tired or chilly. He should then rub dry and dress quickly.[3]

Mineral baths are baths of water containing various natural or artificial mineral salts. Certain mineral springs — those of Arkansas and West Virginia, for example — are much resorted to by invalids.

The *Turkish bath* is a valuable method of cleansing the body and equalizing the circulation, and is generally preferred to the *Russian bath*, where the air is hot and moist. But after the bath, the bather should remain in the waiting-room for a considerable time before venturing

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[1] 100° to 130° F. [2] 110° to 200° F.

[3] Salt water, being more dense than fresh, is much easier to float and swim in, and is for this reason preferred by bathers. The weight of the live human body, with the lungs healthy and inflated, is generally less than the same bulk of water; hence, it need not sink in either fresh or salt water. Sometimes persons do sink because they become alarmed, and, in their fright, fail to inflate the lungs, but raise the arms, thereby submerging the mouth and nostrils.

into the outer air, and then should be well wrapped up and should not expose himself to draughts by standing on street corners, or by riding in open vehicles. He may, to advantage, take a moderate walk.[1]

The ancients esteemed *sun baths* for their remedial effects, and had places arranged in their gardens and buildings where the body could be exposed to the sun's rays (*a*). At the present time, much value, in certain quarters, is attached to the sun bath.[2] In some parts of Germany, *mud baths* are used for their supposed medicinal effects. So milk, blood, broth, and oil are in some places applied to the skin as nourishing agents. Rubbing with oil or vaseline after a bath is known as a *Roman bath*, and is sometimes of value in softening harsh skins and increasing warmth.[3]

97. Adaptation of Baths. — Temperate and tepid baths, which promptly quicken the flow of blood and make the skin glow, agree with most persons, whatever their age and condition. But the tendency is, on account of the comfort they afford, to prolong them beyond the limit of safety, and then they are followed by chilliness, muscular debility, depression of spirits, and sometimes by inflammation of the throat or lungs. It is desirable to become

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[1] In the East, where the Turkish baths are very thorough and are accompanied by much shampooing and friction, the "skin of only one week's date, when collected, is often as large as one's fist." Sydney Smith, in a letter from a hot bath in Germany, says: "They have already scraped enough off me to make a curate."

[2] Some institutions, as the New York Hospital and the Hospital for Crippled Children, have their *Solaria*, or sun-rooms, in which certain feeble persons are placed each day.

[3] The South Sea Islanders are said to anoint the body freely with the oil of the cocoanut before and after bathing in the sea. This is supposed to increase their powers of endurance in the water.

accustomed to cool water if we wish the tonic effects of bathing. This can often be accomplished by gradually lowering the temperature of the bath a little each time, or by following up a sponging with tepid water by one with cool water.[1] It should, however, be quickly performed in a warm room, and be accompanied by a brisk rubbing of the skin.

For very young children, a sponge or dip bath of tepid water is desirable each day or on alternate days. But the child should gradually become accustomed to cool water.

Older children who frequently exercise in the open air may bathe to advantage daily in very cool water, if the bath be a short one, and followed by brisk friction. Many adults are benefited by such daily bathing, and persons who work in a dusty atmosphere may need even more than one bath a day. If, from any cause, the entire body cannot be bathed, the bathing of the head, neck, chest, and feet will afford comfort and strength. In the case of old and feeble persons, whose circulation is sluggish, tepid water alone should be used.

98. The immediate effect of very cool or cold water applied to the skin is to chill the surface of the body ("the first shiver"). It lowers the temperature, produces pallor by driving the blood inwards, and gives rise to the appearance called "goose skin," through contraction of the skin muscles, especially those attached to the hair follicles. In

[1] Such bathing, lasting only from five to eight minutes, is valuable in the morning, on rising, for most people. Sometimes a few drops of ammonia-water or some salt, added to the water of a bath, renders it more stimulating. Children and feeble persons have repeatedly become accustomed to cool and even cold baths by gradual training as above.

a vigorous person, reaction promptly follows. The skin becomes warm from the blood returning to it in increased amount. The bather should leave the bath before the secondary effects ("the second shiver") appear, *i.e.* chilliness, lassitude, blueness of lips and finger nails, and in some instances great prostration. This second shiver is always a danger signal.

99. Hot and cold baths are to be used with caution, especially by persons with heart disease, or far advanced in consumption, or when very feeble or greatly fatigued. Hot-water baths are more cleansing than cold-water, but are generally more relaxing, and have not the tonic properties of the latter. Hot water applied to the skin promptly stimulates it, and is as promptly followed by chilliness, lassitude, and prostration, if the bather is not robust and active, or if the bath-room is cool. Once a week is often enough to use a hot-water bath. If frequently resorted to, danger may result from over-stimulation and subsequent depression of the heart and nervous system. Persons in robust health may enjoy frequent bathing in cold water, even in cool rooms, if the bathing occupies but a short time and is followed by brisk friction; but the practice is attended with risk.[1]

QUESTIONS.

1. Why is bathing important to health?
2. Upon what do the times, manner, and hours of bathing depend?
3. What is the proper bathing for different ages?

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[1] There are people, undoubtedly, who can break the ice in ponds, and plunge in with impunity, but most persons cannot. Sometimes bathing must be so nicely adapted to the individual's needs that only a physician can decide what kind it must be, and how and when it is to be resorted to.

4. What effects follow proper and what improper bathing?
5. What are the effects of cold and warm water respectively?
6. What are the best times for bathing?
7. How are water baths classified, and what can you say of the several kinds?
8. What other baths are there? Of what use are they?
9. What can you say about soap?

CHAPTER VIII.

CLOTHING.

100. Uses of Clothing.—*First.* The great object of clothing is to prevent the loss of animal heat. Clothing not only hinders too rapid evaporation from the body, but being non-conducting, it prevents a loss of heat from direct contact with the outer air and other cold objects, and materially checks radiation. We are thus enabled to bear more easily sudden changes of temperature.

Second. It economizes the animal forces by the retention of heat and by the comfort it affords. An exhausting expenditure of nervous and muscular energy to create animal heat is thereby avoided, and the food, instead of being used up as fuel in supplying a constant waste, is saved for the construction and repair of tissue. It is well known that both human beings and animals, when warm, require less food and can do better work than when cold.

Third. It protects the body from heat, dust, and other external sources of injury, particularly from the injurious influences of the winds, damp air, rain, hail, and snow, and from contact with poisonous substances.

Fourth. Clothing is a covering and an ornament for the body.

101. Proper Clothing.—Nature provides the inferior animals with a natural covering that is beautiful, complete, and admirably adapted for varying seasons and climates; but man, in this as in other respects, is left with a power

of choice, and must take the consequences. "Clothing should be made to fit the form, and not the form the clothing." It should be chosen for comfort rather than for style, though clothing may be both comfortable and stylish. It should be of the quantity, quality, and color best adapted to the varying needs of the wearer. It should be light, dry, clean, and properly ventilated.

102. Bad Effects of Tight Clothing.—We have already seen that *freedom of movement* is indispensable in the various forms of muscular exercise, and in the performance of vital processes. It follows, therefore, that any clothing which interferes with this freedom is to be avoided.

Heavy or tightly fitting head coverings overheat the scalp and exclude the air.[1] Their pressure obstructs the blood supply and the free action of the nerves, inducing headache and baldness. Tight cravats, collars, and bands press upon the windpipe and the important blood-vessels, nerves, and other structures of the neck, thereby impeding the passage of air, blood, and nerve currents, and producing discomfort, a sense of fulness in the head, headache, and disturbance of vision. "Some years ago many British soldiers fell victims to close military stocks, which, obstructing the easy return of the blood from the head, produced cerebral congestions and apoplexy."

The shoulders should bear a large part of the weight of clothing. The pressure of arm-hole seams and shoulder bands upon the arms below the shoulder-joints hinders the free play of those important members, and is an obstruction to proper muscular exercise.

The normal movements of the lungs, heart, and other

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[1] The helmet hats now worn by soldiers are of light weight, good color, and well ventilated. Formerly soldiers' head-gear was tight and heavy.

organs are disturbed whenever the free movements of the ribs are restrained by tight coats, corsets, or vests (*a*). Such compression, more than any other, deranges the vital processes, and produces suffering which is often referred to other causes. Among its effects are lassitude, headache, cold feet, shortness of breath when exercising, dyspepsia, faintness, many derangements of the functions of internal organs, and sometimes deformities of the chest.[1]

Tight belts impede the movements of the abdominal organs, and may cause various disorders. Elastic bands in garters and shoetops are sometimes so tight as to affect the circulation of blood in the parts pressed upon.

Fig. 40.

Composite photograph of girl in corset and without corset; an exact reproduction. Note the two outlines at the waist. This is not what is called "tight lacing," but from a working costume. (DICKINSON).

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[1] It is well known to medical examiners of life insurance companies and for the army and navy, that the measurement around the middle of the chest, even with the clothes on, should show at least *two inches* difference between the chest expanded by full inspiration and contracted by forced expiration. The difference, in health, is from 2 to 4 inches, the average being about 3. Now, a chest that expands (after being emptied as far as possible of air) only 1¼ to 1¾ inches with tight garments on, will often expand 2½ to 3½ inches with the garments removed. This latter degree of expansion is the normal one, and any garment that lessens it is too tight.

103. No articles of dress, perhaps, need to be so nicely adjusted, for the comfort of the individual, as boots and shoes.[1] If too large, they cause discomfort, corns and bunions, and loss of temper; if too small, they do all this and

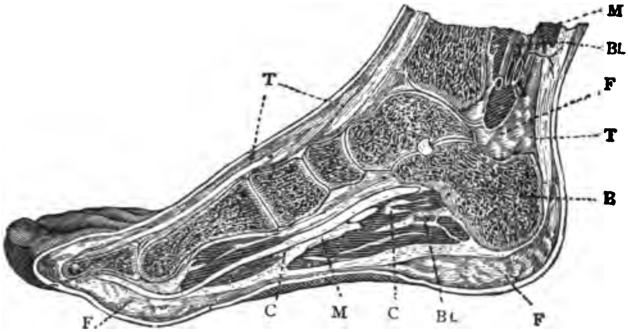

Fig. 41.

Vertical section of right foot, showing the arches and the relations of the various structures.

B, bones.	T, tendons.	C, connective tissue.
M, muscles.	F, fat.	BL, blood-vessels.

more; they interfere with muscular exercise, cause cold feet, pain, and deformity.

In shoes modelled upon lasts of wrong shape the weight is thrown upon or toward the outer side of the foot, instead of being borne, as it should be, directly over a line drawn from the middle of the heel to the middle of the big toe.[2]

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[1] "It is said that the Duke of Wellington, being questioned as to the most essential requisite of a soldier's clothing, replied, 'A good pair of shoes.' What next? 'A spare pair of good shoes'; and even thirdly, 'A spare pair of soles.'" — MAPOTHER, *Lectures on Public Health*.

[2] Unfortunately, normal feet are rare, because properly constructed and fitting shoes are by many not considered stylish enough. It is not a question of square, round, or pointed toe. The shape is a matter of fancy. But the selection of a shoe is a question of free motion of instep, ankle, and toes, and comfort from non-pressure.

If to such shoes high heels are added, and especially if they are near the middle of the soles, an unnatural mincing gait, not unattended with danger, is the result. The weight of the body being thrown forward upon the toes, the ligaments of the various joints are strained, especially those of the spinal column, knees, ankles, and toes. The muscles of the back of the leg are deprived of their share of work. Overriding and other deformities of the toes are produced; and in some instances, important tendons which pass around the outer ankles are thrown out of their grooves, and lameness results.

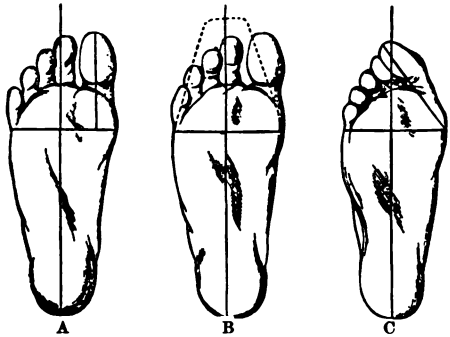

Fig. 42.

A, normal foot, proper position of toes.
B, normal foot, with an outline of the front part of an improper shoe.
C, toes crowded out of position as result of wearing such an improper shoe.

Fig. 43.
An improper shoe.

Fig. 44.
A proper shoe.

Boots and shoes should fit the feet snugly, especially over the instep, but should allow free movements of the various joints. They should have broad soles, low and broad heels,[1] should not cramp the toes, should be hollowed out but little on the inner side, and should be so shaped that the weight of the body may be borne where nature intended it to be. These simple requisites will give us sensible, comfortable, and good-looking foot coverings.

104. The Quantity of Clothing should be sufficient to keep the body comfortably warm, and should be increased or diminished with the change of season or of temperature. It is, of course, important that the body should be able to bear slight changes in temperature; but the practice of *hardening by exposure* (as is sometimes done with the limbs of little children) is attended with danger.[2] Neither is it prudent to throw aside warm clothing before the actual onset of warm weather, or to delay putting it on till cold weather has far advanced.

105. On the other hand, too much clothing has also its bad effects. It induces free perspiration, which, retained in contact with the skin, proves an irritant. The skin, from being unaccustomed to the stimulating effects of a tonic atmosphere, becomes susceptible to very ordinary changes in temperature. Hence, thick wrappings worn about the neck, such as tippets or fur collars, tend to make one subject to throat affections, especially if the

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[1] Not more than half an inch high. For young children spring heels may be best. The shoe should be a little longer than the foot.

[2] Proper care of the skin, by systematic bathing and well-regulated clothing, will in reality harden, while exposure of tender skins is dangerous to health and life.

wrappings be removed where there is any draught of air.[1]

As far as possible, clothing should cover all parts of the body equally. Hence, padding a part of the clothing, while other portions are made quite thin, is objectionable. So, too, "full dress," in the fashionable sense, is not full enough in a cold room, or on going out of an overheated room in cold weather. Warmth, however, depends more upon the material and structure of the clothing than upon the quantity.

106. Lightness, Ventilation, and Warmth are desirable qualities in clothing, and may be combined in a loosely woven cloth, the meshes of which contain confined air. Air is one of the best non-conductors of heat known; but if left free, it abstracts heat by promoting evaporation from the skin, and by keeping up a continual contact of fresh unwarmed particles. Confined air, however, prevents rapid evaporation, as well as radiation and the actual contact of colder bodies. Hence mittens are warmer than gloves, because they contain more confined air, and also because the fingers are in contact. Two pairs of cotton stockings afford more warmth than one pair, because of the air between them. For the same reason, two undershirts may be better than an overcoat, and are an especial protection against sudden exposure. So woollen stockings

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[1] "A regiment of infantry, according to Baron Percy, being on their march in hot and stormy weather, the soldiers became heated and out of breath. The colonel permitted them to take off their stocks. Soon afterwards they entered a gorge of the Vosges, exposed to the northwest wind, without covering the neck. On the following day 73 soldiers were sent to the hospital, the greater part attacked with inflammatory sore throat, and, in a few days, more than 300 others were taken sick, apparently from the same exposure." — DUNGLISON, *On Human Health.*

drawn over shoes are more comfortable, when walking through snow, than even thick shoes. Felt shoes are warmer than leather ones. Loosely knit head coverings worn by women are both light and very warm.

107. Clothing frequently worn needs a texture that will admit fresh air through it, or should be so arranged that the air may pass beneath it. Tightly woven and close-fitting underclothing or impervious rubber outer garments do not allow the impurities from the skin to escape. Much better are the loosely woven, net-like under-garments now made, and the modern gossamers, which in some instances are ventilated by valve-like openings under the arms and on the back.[1] While it is prudent to provide ourselves with overcoats, wraps, and rubber garments during a storm, they should be removed, or at least unfastened, when indoors or when not exposed to inclement weather.

108. Dryness and Cleanliness. — Wet clothing chills the skin, cools the air in contact with it, hinders the escape of impurities, and should be removed as soon as possible, the body made dry and warm, and dry clothing substituted. If caught in a storm when unprovided with wraps, the increased animal heat afforded by walking or other continuous exercise will usually avert evil consequences.

It is important that clothing for the night, including bed coverings, should be light, dry, airy, and warm.[2] There

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[1] The oil-skin coats worn by sailors, and made of cotton cloth treated with alum, linseed oil, etc., are light, water-proof, and by their texture ventilated. Rubber boots and overshoes, worn frequently and for a long time, are likely to cause chilblains. An outside garment of leather, lined with wool, is comfortable for those exposed to severe cold.

[2] A few folds of newspaper put between two blankets or other covers will furnish sufficient bed-clothing for a bitter winter's night. In addi-

should be a complete change of clothing at night. Much wakefulness and feverishness is undoubtedly due, if not to impure air, to unaired clothing. As Miss Nightingale puts it: "Feverishness is generally supposed to be a symptom of fever, — in nine cases out of ten it is a symptom of bedding."

Unclean clothing, besides keeping the skin in a foul condition, becomes a receptacle for germs of disease.[1] Clothing worn by attendants in cases of scarlet fever, small-pox, or other contagious diseases should be burned or disinfected as soon as possible (*a*).

109. Color and Dyes. — Color in dress is not merely a matter of taste, but is an important consideration from a sanitary standpoint. Benjamin Franklin demonstrated, by means of various colored cloths placed upon the surface of snow under the sun's rays, that black was the warmest color, and white the coolest. Dark colors are best for general use in cold weather, and white, gray, etc., in hot.[2]

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tion to the superior non-conducting quality of paper, its porosity allows a ready escape of the insensible perspiration without the cooling effects of evaporation. The sleeper is kept, therefore, dry and warm, and never experiences that clammy dampness which results from thicker bed-clothing; nor does he suffer from an oppressing weight. He will soon accustom himself to the rattle of the paper. Paper is also used to advantage in the shape of undervests, and in the soles of shoes. As to bed-clothing, so-called "comfortables" are sometimes very uncomfortable, on account of their weight, which impedes the circulation and prevents the escape of the insensible perspiration, and the sleeper awakes in the morning damp and even uncomfortably cold.

[1] Skirts and trousers so long that they gather and hold filth from the streets are for sanitary reasons to be deprecated.

[2] "Clothing has frequently been the agent through which infectious disease has been propagated. Judging from Stark's observations on the power of absorbing odors, the probability is that contagion is absorbed after the same manner. Stark found that the absorption of odors was in

Owing to the demand for cheap and bright-colored clothing, poor material, sometimes colored with cheap and poisonous dyes containing arsenic, copper, etc., is thrown upon the market. Clothing, such as socks, tights, or undershirts, is dangerous if so colored, since it usually comes in direct contact with the skin.[1] The dyes act with especial force in hot weather, when they are dissolved by perspiration.

110. Material. — In our variable climate, *woollen* under-garments should be worn, of varying thicknesses for the different seasons. Intermediate garments, such as waists and vests, should be made with especial reference to wear, while the outer garments may be arranged with greater regard to the mere appearance. Woollen or silk cloth is a better retainer of heat than cotton or linen. Woollen cloth is filled with confined air, and its ability to retain moisture, whether from the skin or from outside, prevents the cooling effects of rapid evaporation. Hence flannel and merino, in our changeable climate, make excellent under, intermediate, or outer garments.[2]

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proportion to the hygroscopic absorption, and that it depended in a great measure upon color — black absorbing most, then blue, red, green, yellow, and lastly white. For a nurse, a dark woollen garment is the worst and light-colored cotton best." — *Dictionary of Hygiene and Public Health.*

[1] "The symptoms produced vary somewhat; usually they consist in redness and staining of the part, followed by swelling, itching, and smarting, with the formation of little blisters or vesicles, which break and give exit to a discharge. The part affected then becomes decidedly painful, and is occasionally greatly swollen. There is also a great deal of constitutional disturbance, and in fact the sufferer is quite ill. The peculiar staining of the skin, coinciding with the particular hue and pattern (bars, stripes, etc.) of the colored article, at once suggests the cause of the mischief." — *The Skin and its Troubles. Health Primer.*

[2] The favorite prescription of the celebrated English physician, John Hunter, for the rearing of children, was "plenty of milk, plenty of

Silk is the next most suitable material, especially for undergarments; then *cotton;* and lastly *linen.* Linen being a good conductor, and thin and closely woven, is too cool for use in winter or in a changeable climate. Neither is it suitable for an undergarment where the wearer is working hard or is exposed to great heat and draughts of air. Linen, cotton, or silk garments may be worn next the skin, with flannel over them, by those whose skins are irritated by flannel.[1]

QUESTIONS.

1. Why does clothing keep us comfortable, and what other use has it?
2. What are the evil effects of tight clothing? Illustrate.
3. What is said of too tight and too heavy clothing, respectively?
4. What are the three desirable qualities in clothing, and how are they best combined?
5. How and why may air be made useful in our clothing? Illustrate.
6. Why should clothing have ventilation?
7. What are the bad effects of wet clothing?
8. Of what sort should our bed covering be?
9. What may result from unclean clothing?
10. Of what importance is the color of clothing?
11. What bad effects have improper dyes?
12. What is to be said of the different materials for clothing?

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sleep, and plenty of flannel." It is stated by physicians in hot countries that the wearing of wide flannel bandages (doubled) over the abdomen is a capital safeguard against cholera, bowel affections, and a sudden check of the perspiration. Street laborers, soldiers, and factorymen find by experience that they can wear flannel with comfort when exposed to varying changes in the atmosphere and at hard work. It is said that in rainy weather sailors wring out the water from their woollen jackets and put them on again, seldom catching cold.

[1] Cloth or clothing should not be bought simply because it is cheap. Much of the cheap cloth is made of odds and ends, rolled or otherwise pressed into shape, and is known as "shoddy." It is of little value for clothing.

CHAPTER IX.

DIGESTION.—THE CONVERSION OF FOOD INTO TISSUES.

111. Nutrition.—The maintenance of life, our growth and development, and the production and utilization of various forms of energy, all depend upon the vitality of the innumerable cells of which the body is composed. This vitality is largely influenced by food. "From the food the blood is fed; from the blood the tissues are fed." For the proper nourishment of the body, there must be a daily income of food and oxygen, and a daily outgo of the refuse of food and tissues in the shape of *wastes*. These, if retained in the body for any length of time, decompose and are likely to form poisons. Wastes are excreted mainly by the lungs, skin, and kidneys, in the form of water, carbon dioxide, and urea. The large intestine gets rid of such materials as skins of fruit and vegetables, and food substances that have not been converted into blood, all associated with water and refuse secretions.

Nutrition, which accomplishes all this, is a complex process. It involves the reception, digestion, and absorption of food, the absorption of oxygen, the conveyance of absorbed food and oxygen to all parts of the body, the building up of tissues by assimilation, the breaking down of tissues, and the taking up of waste materials thus produced and conveying them to excretory organs for expulsion from the body.

112. Digestion. — Man, being an omnivorous animal, is able to live on a large number of food substances. The conditions of his life demand that this should be so. Part of his food he can eat in its raw state, and dispose of with comfort; the rest he must prepare by cooking. All of it must be in liquid form to be absorbed, and most of it must be transformed before it can become blood. For this transformation and liquefaction, mechanical and chemical agencies are necessary.

The process by which food is converted into blood in the body is called *digestion*. The digestive organs consist of the alimentary canal and its accessory organs, the teeth, salivary glands, liver, and pancreas.

In animal organisms whose food is of an elementary character, these organs are few in number and of simple structure. The amoeba has no specific digestive organs. It can take food into its body through any portion of its substance, and cast out the waste in the same way. In man, the digestive organs and the process of digestion are complex. His food is mechanically broken up by means of the teeth and the churning motion of the stomach. It is chemically acted upon by secretions from the salivary glands, stomach, liver, pancreas, and small intestine. All of these secretions owe their efficacy to substances within them called *ferments*.[1] Each ferment acts upon particular food substances. Some act best in an alkaline, some in an acid medium. All are most active when the body is at its normal temperature.

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[1] That is, ingredients which, by their presence under favorable circumstances of heat and moisture, change the chemical constitution of substances for which they have an affinity. The action of yeast, in bread-making, is an example of the action of a ferment. Unorganized ferments are sometimes called *enzymes*.

113. The steps by which food is converted into the tissues of the body are: *mastication*, or chewing; *insalivation*, or mixing with the saliva; *deglutition*, or swallowing; *stomach* and *intestinal digestion; absorption*, the taking up of the digested material by the absorbents (veins and lacteals); *circulation*, the conveyance of this material by the blood to all the tissues; and *assimilation*, the appropriation of it by the cells of the tissues, according to their needs.

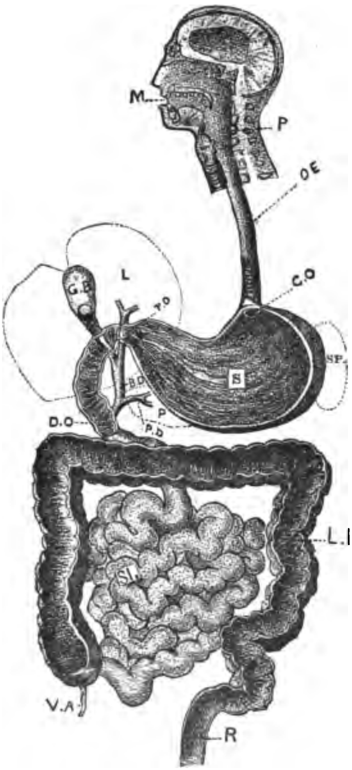

Fig. 45.

The Alimentary Canal.

M, mouth. VA, vermiform appendix.
P, pharynx. LI, large intestine.
OE, oesophagus. R, rectum.
S, stomach. GB, gall-bladder.
CO, its cardiac opening. BD, bile duct.
PD, pancreatic duct.
PO, its pyloric opening. DO, opening of the common duct into small intestines.
SI, small intestine.

Accessory Digestive Organs.

L, liver. P, pancreas. SP, spleen.

114. The Alimentary Canal is a musculo-membraneous tube, which extends from the lips downward throughout the trunk, and in adults is about thirty feet in length. *In it the food is digested.* It is lined throughout its entire length by a delicate but firm tissue, which is continuous with a similar lining within the air passages, the whole being known as the *mucous*

membrane.[1] This membrane is richly supplied with blood-vessels for its own nourishment, and, in certain parts of it, these vessels with lymphatics are peculiarly arranged to carry on the process of absorption. It is well supplied with nerves. In addition to the gastric and intestinal digestive juices which the mucous membrane secretes, it is supplied with a viscid fluid called *mucus*, which protects it and enables its opposing surfaces to glide easily upon each other in the various movements of the canal, incident to digestion.[2] The wall of the digestive tract is made up of fibrous connective tissue for strength, and, for the most part, of two layers of involuntary muscular fibres, one longitudinal, the other circular. These, by alternately contracting, push the food along.

The alimentary canal varies in its different parts in size, form, and structure, thereby forming the mouth, oesophagus, stomach, and intestines.

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[1] The mucous membrane varies in thickness and general arrangement in its various portions. In the nose and air passages it is thin and smooth, in the mouth and throat somewhat thicker; upon the tongue it is covered with *papillae,* in the small intestine with very soft projections called *villi;* and in the stomach it is thrown into ridges. The cells covering the surface of the mucous membrane are epithelial cells, and together constitute the epithelium. Sometimes the mucous membrane is called the internal skin, from a similarity to the external skin.

[2] Ordinarily, in health, there is just sufficient mucus to act as a lubricant. But in some, young children especially, whose tissues are very sensitive, an excess of mucus is readily induced by an irritation of the mucous membrane, through indigestible food, exposure of the skin to sudden changes in temperature, and by other means. This excess of mucus may, by coating proper food, interfere with its digestion. On the other hand, if the mucous membrane is not torn, injured, or diseased, such an excess, by coating improper articles that have been swallowed, will generally prevent any injury that might otherwise result from them.

115. The Mouth is the commencement of the canal. It consists of the lips in front; a cheek on each side; a bony

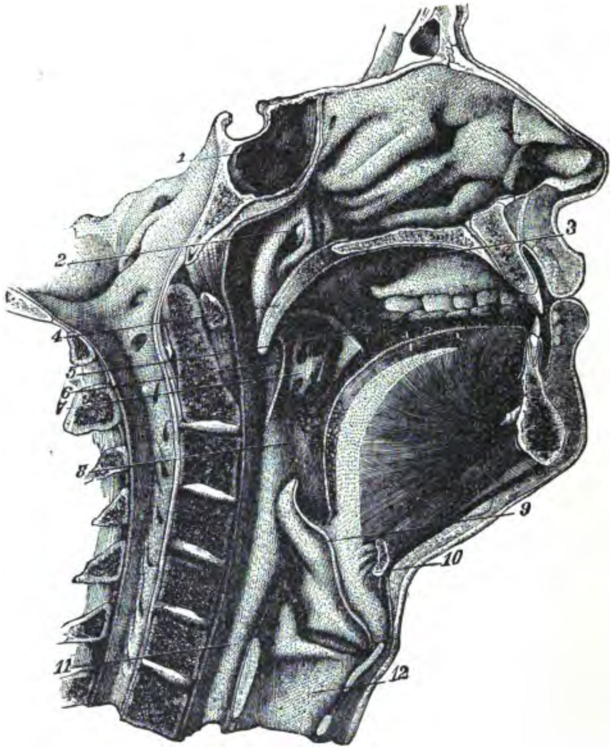

Fig. 46.

A Vertical Section through the Middle of the Face, Neck, and Upper Vertebrae.

1, Cavity in the skull.
2, opening of left Eustachian tube.
3, the hard palate.
4, the soft palate.
5, muscular wall in front of tonsil.
6, muscular wall behind the tonsil.
7, the left tonsil.
8, pharynx, or throat.
9, the epiglottis.
10, the hyoid bone.
11, oesophagus.
12, the cavity of larynx.

roof, or hard palate, separating the mouth from the cavity of the nose, or nasal passages; and the tongue below. In

the back part of the mouth is the soft palate, or curtain, that separates the mouth from the pharynx, and which is raised in the act of swallowing. The mouth contains the teeth, and is moistened by the *saliva*.

116. **The Pharynx**, or throat, is at the first bend of the alimentary canal downwards. It is, in general, funnel-shaped, with its upper portion, or roof, rounded like a buggy-top. It is slightly constricted in front, on each side, by two muscular pillars, "the pillars of the fauces," between which are almond-shaped bodies called *tonsils*. Above and behind the soft palate the pharynx communicates with the nose by two openings, known as the *posterior nares*, one for each nasal passage. In the upper part of the throat, on a line with the floor of the nose, are the openings of two ducts, named the *Eustachian tubes*,[1] which connect the mouth with the organs of hearing. At the lower part of the throat, in front, is the *larynx*, or voice box, which opens into the windpipe or tube leading to the lungs. Surrounding the pharynx are three obliquely placed muscles, styled the constrictors

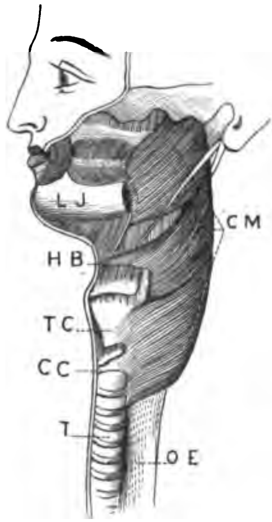

Fig. 47.

The Location of the Constrictor Muscles.

LJ, the front part of lower jaw, the remainder being cut away to show parts beneath.
HB, the hyoid bone.
TC, thyroid cartilage of larynx.
CC, cricoid cartilage of larynx.
T, trachea.
OE, oesophagus.
CM, the constrictor muscles—superior, middle, and inferior.

[1] Inflammation of the throat sometimes extends through one or both of these ducts, causing earache or deafness.

of the pharynx. These overlap each other, and, with other muscles, are concerned in the act of swallowing.

117. The Oesophagus, or gullet, is the next portion of the alimentary canal, and connects the pharynx with the stomach, passing through the neck and chest, and ending just below the diaphragm. It lies in front of the spinal column, and its upper part is immediately behind the windpipe. The alternate contraction and relaxation of the muscles of the oesophagus serve to propel its contents toward the stomach. The wave-like motion resulting is called *peristalsis*, and is similar to that of the intestines.[1]

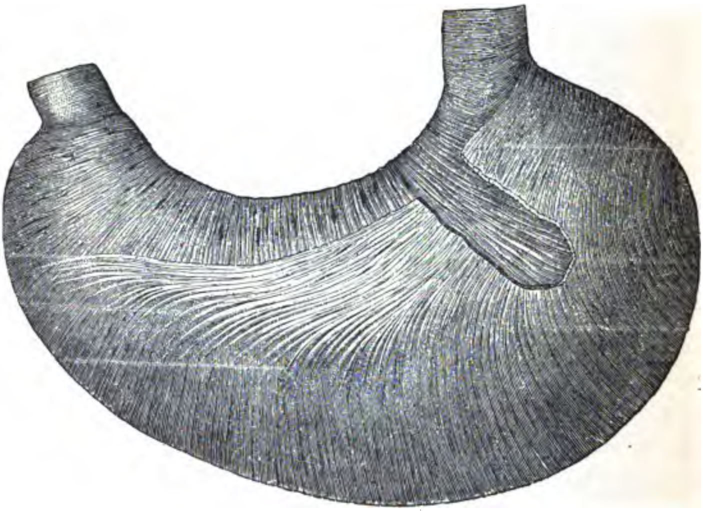

Fig. 48.
The Muscles of the Stomach, one part removed to show underlying fibres.

118. The Stomach is somewhat pear shaped, its larger end being upon the left side of the body, beneath the ribs,

[1] This peculiar motion is also called vermicular, or worm-like.

just under the diaphragm, and in contact with the spleen. The smaller end is on the right side of the body, under the liver. When moderately filled, the length of the stomach is about twelve inches, and its greatest diameter four inches.[1] Its capacity is about four pints.

The stomach has two openings: one where the oesophagus enters, called the *cardiac*[2] opening, because of its

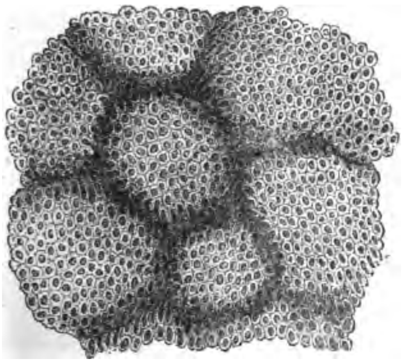

Fig. 49.

The Internal Surface of the Stomach, from which the epithelium has been removed, showing the openings of gastric glands. [Magnified 20 diameters.]

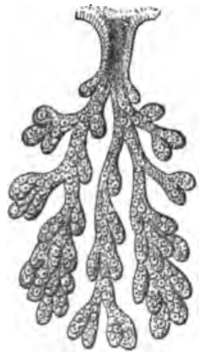

Fig. 50.

A Gastric Gland.

location near the heart, from which it is separated by the diaphragm; the other is styled the *pyloric*, or gate opening, because it is provided with a muscular valve known

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[1] The stomach varies in size more than any other organ in the body. When empty, it is shrunken and flattened, and overlapped by the liver. When very full, it comes close behind the abdominal wall, and the "pit of the stomach" is no longer visible. The stomach of the glutton becomes distended and does not readily regain its normal shape. When very much distended, it often presses upon the heart, causing distress and the symptoms of heart disease.

[2] Derived from the Greek καρδίη, "heart."

as the *pylorus*, or "gate-keeper," the object of which is to prevent the premature exit of food from the stomach.[1]

The lining of the stomach is very soft and delicate. When the cavity is almost, or entirely, empty, the lining is arranged in folds. It is amply supplied with mucous glands and with gastric follicles, *i.e.* glands which secrete a digestive fluid,—the gastric juice.

The muscles in the walls of the stomach are involuntary, and are arranged in three layers,—the oblique, the circular, and the longitudinal. Their alternate contraction and relaxation serve to agitate thoroughly the contents of the stomach and to mingle them with the gastric juice.

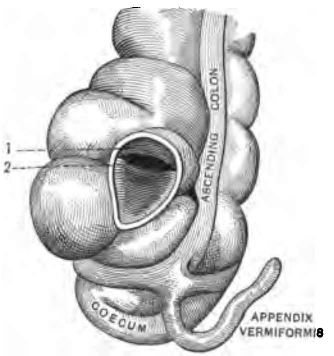

Fig. 51.

Ileo-coecal Valve and Adjacent Parts. (SAPPEY.)

1, end of small intestine in large intestine.
2, ileo-coecal valve.

119. The Intestines.—The remaining part of the alimentary canal consists of the intestines, or bowels, which lie mainly in the abdominal cavity, but end in the lowest part of the pelvic cavity. These are divided into the small and large intestines,—the former being from twenty to twenty-five feet in length and averaging one and a third inches in diameter, the latter about five feet in length and two inches in diameter.

[1] When the stomach contains a large amount of indigestible food, and has been too long in action, its muscular tone diminishes, and the valve no longer prevents the exit of improper material. Thus indigestible substances accidentally swallowed may pass the "gate-keeper," though sometimes their passage is greatly delayed and causes much discomfort.

120. The Small Intestine is coiled upon itself and extends from the pylorus to the large intestine, which begins in the right lower portion of the abdomen. Its opening into the large intestine is guarded by the ileo-coecal valve, an arrangement which readily admits of the passage of refuse material into that intestine, but interposes a usually serviceable barrier to its return.

The intestine is held in place principally by the mesentery, a double fold of serous membrane[1] attached to the spinal column; but it so envelops the intestine that its necessary peristaltic movements in the transmission of food are not interfered with.

Fig. 52.

Section of Small Intestine, showing Valvulae Conniventes (TESTUT). Wide perpendicular line = muscle; line on left = fibrous coat; line on right = mucous membrane.

The lining of the intestine is very vascular and velvety. Throughout the larger part of the canal it is arranged in transverse, shelf-like folds, more or less circular in form, which, from their winking motion as they sway backward and forward in the fluids of the intestine, are called *valvulae conniventes*. There are about eight hundred of these delicate folds. They retard the passage of food, and so expose it for a longer time

[1] A membrane which secretes a thin whey-like fluid called *serum*. A similar membrane, under the name of the *peritoneum*, incloses, for the most part, all the abdominal viscera in the same way.

to the action of the digestive fluids. They also provide a very large surface for secretion and absorption.

The characteristic velvety condition of the mucous membrane is due to its millions of minute elevations, presenting a general appearance of plush, and known as *intestinal villi. Through them the process of absorption is*

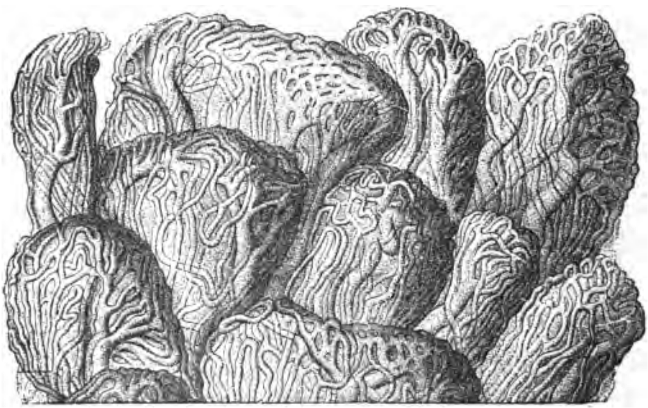

Fig. 53.
Villi of Small Intestine, with their superficial arteries and veins distended.
(Magnified 100 diameters.)

mainly effected. Each villus is composed of a framework of connective tissue, upon the free surface of which is the epithelium, — a single layer of cells. In the centre of the framework is a small vessel, with a closed end near the upper extremity of the villus. This is called a *lacteal*,[1] and is an offshoot of a system of absorbent vessels distributed throughout the body, named *lymphatics*.

[1] So called because during digestion it is filled with a milk-white fluid, consisting mainly of fat, which it has taken up from the intestine. During the intervals of digestion these vessels are not readily seen. Sometimes the lacteals are double.

The lacteals empty into the *receptaculum chyli* (*i.e.* receptacle of the chyle), a pouch lying upon the lumbar vertebrae. This pouch connects with the *thoracic duct*, a small tube which extends upwards and empties into the left subclavian vein, — the large vein, under the left clavicle, or collar bone. Within each villus are involuntary muscular fibres and a network of minute blood-vessels (veins) that empty into a large vein, called the *portal vein*,[1] which conveys to the liver certain products of digestion.

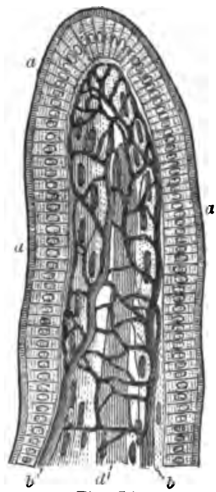

Fig. 54.

A Vertical Section of an Intestinal Villus.

a, epithelial cells.
b b, blood-vessels entering and leaving the villus.
d, lymphatic vessel (lacteal) in the centre.

In the mucous membrane of the intestine are numerous follicles, some of which secrete mucus and some a digestive fluid known as intestinal juice. Within about three inches of the pylorus the duct from the gall-bladder of the liver and that from the pancreas open into the intestine, admitting two more digestive fluids, the bile and the pancreatic juice.

121. The Large Intestine begins as a rounded cavity, — the *coecum*, — ascends upon the right side of the abdominal cavity to the under surface of the liver, crosses over to the left, underneath the stomach, and descends upon the left side to the upper and left portion of the pelvis, where its caliber becomes smaller. It then makes a bend, enters the pelvis, becomes the *rectum*, and ends as the lower open-

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[1] So called because it enters the liver at what was once called the *porta*, or gateway.

ing of the alimentary canal.[1] The coecum has a cylindrical tube, from one to five inches long, projecting from its lower part, which tube is known as the *appendix vermiformis*. Its uses are not known. Sometimes seeds of small fruit lodge in it. Usually these do no harm ; but occasionally an inflammation (appendicitis) is started by their presence in the appendix, though such inflammation is more often the result of excessive activity of bacteria upon decomposing food. It is wise, when eating fruit with small seeds, to eat also bread or some other food which will be likely to entangle the seeds and pass them beyond the opening of the appendix.

While it is true that the large intestine is able, to a limited extent, to absorb certain food substances, it is essentially the sewer of the body and contains refuse. The daily evacuation of this waste material is a matter of the greatest importance, to avoid decomposition and the absorption of poisons into the blood (*a*).

122. Accessory Organs of Digestion. — **The Teeth** are the organs of mastication, and are well adapted for the breaking and grinding of food, to prepare it for the softening and digestive action of the saliva. They assist, also, in the use of the voice, and in preserving the symmetry of the face. Each tooth has three parts: the *crown*, or body, seen in the mouth; the *root*, embedded in a socket in the jaw; and a *neck*, the constricted portion between the other two. This is supported by the gum, a dense fibrous tissue covered with mucous membrane.[2] The bulk of

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[1] The ascending part of the large intestine is called the *ascending colon;* the transverse part, the *transverse colon;* the descending part, the *descending colon.*

[2] The gums of old people who have lost their teeth shrink and sometimes become very hard, enabling them to munch their food.

the tooth is composed of *dentine*, resembling bone, and sometimes called tooth-bone, or ivory. On the crown, covering the dentine, is the *enamel*, the hardest tissue in the body.[1] Strong as it is, it may be broken and the decay of the teeth rendered probable by the cracking of hard-shell nuts or other hard substances between them. Covering the root is a thin layer of bone, the *cement*.

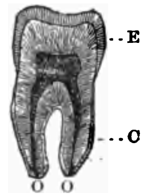

Fig. 55.

A Vertical Section of Tooth.

E, enamel.
C, cementum.
O O, openings in roots for the passage of nerves and blood-vessels into the pulp cavity, represented in figure by darkened centre.

The dentine incloses a cavity in the tooth, which is termed the pulp cavity, and which contains the pulp, a substance consisting of connective tissue, blood-vessels, and terminal nerves. The nerves and blood-vessels enter this cavity through a small opening at the tip of each root.[2] Canals radiate from the pulp cavity to the outer surface of the dentine. Destruction of the enamel at any point, therefore, exposes the entire cavity, and decay results.

123. There are *two sets of teeth:* the temporary, or milk teeth, of early childhood, twenty in number, the first appearing usually about the seventh month of

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[1] The hardness of the enamel varies in different persons. In some it is so soft, from a deficiency of phosphatic salts, that the teeth wear down almost to the gums.

[2] The pulp supplies nourishment to the tooth. When it dies, the tooth loses its translucency and sensibility, and is discolored, and if it be a tooth of the permanent set, is never replaced by a new one, or even by new tooth-structure, but may retain its position in the jaw and do duty for years.

life,[1] the last about the twenty-fourth; and the permanent set of youth and adult life, thirty-two in number, the first appearing about the sixth year, the last, or wis-

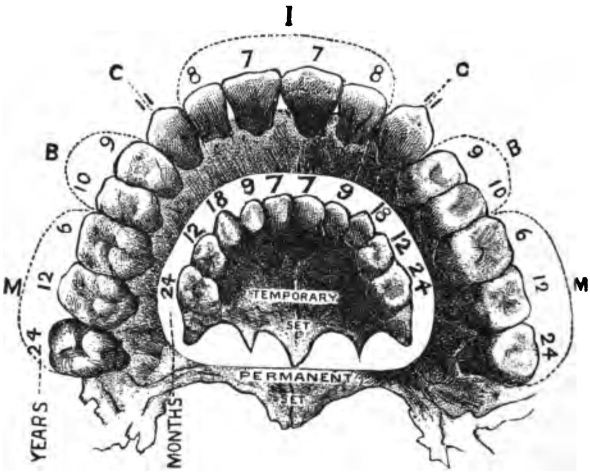

Fig. 56.

A diagram of two upper jaws, representing the location, arrangement, and time of eruption of the temporary and permanent teeth. The relation of the temporary to the permanent teeth is indicated by their position, and by dotted lines connecting them with the permanent teeth. The numerals represent, in one instance, the time of the appearance of the teeth in years; in the other, in months.

I, incisor teeth. C, canine teeth. B, bicuspid teeth. M, molar teeth.

dom teeth, about the twenty-fourth year.[2] The permanent teeth originate near the roots of the temporary teeth, and, as they develop, press upon these roots and cause

[1] From various causes, such as sickness, hereditary peculiarities, or lack of proper tooth-forming food, the appearance of the teeth may be delayed till one year of age, or even longer. Babies are sometimes born with teeth.

[2] The first permanent teeth appear behind the posterior milk molars, before any of the milk teeth are shed, viz., at six years, so that a child of six has twenty-four teeth, — twenty temporary and four permanent.

their absorption, the temporary teeth being eventually shed as little conical "crowns," with convex bases.

Teeth are classified as *incisors*, *canines*, *bicuspids*, and *molars*. In the first or temporary set, there are in each jaw four incisors, two canines, and four molars. In the second or permanent set, there are in each jaw the same number of incisors and canines, four bicuspids, and six molars. The bicuspids[1] replace the molars of the temporary set. The teeth of the permanent set are larger and much stronger than those of the first.

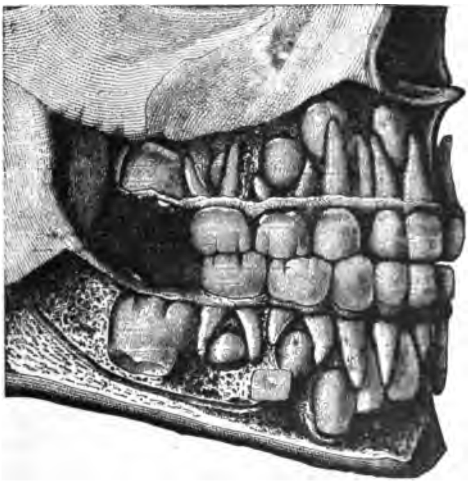

Fig. 57.
Section of Jaws, showing the Temporary and Permanent Teeth.

The incisors, or cutters, are in the front of each jaw, and have chisel-like edges for use in cutting or biting food. Adjoining the incisors are the canines,[2] which are some-

[1] So called, because they have two cusps or points upon their crowns.

[2] The upper canines are sometimes called eye teeth, the lower ones stomach teeth, though they have no peculiar relation to these organs.

what pointed at the edges, like the teeth of dogs. They assist the incisors in dividing the food. The bicuspids are between the canines and molars. They are shorter and thicker than the canines, and assist the molars in crushing the food. The remaining teeth are the molars,[1] or grinders. These teeth pulverize the food, and are especially adapted for the purpose, their grinding surfaces being broad and irregular. This grinding action is effected by the pressure of the lower jaw against the stationary upper jaw, with lateral, rotary, and upward movements, by means of powerful muscles.

124. The Care of the Teeth is a matter of importance. The condition of the teeth of children, as well as adults, should be carefully watched by a reliable dentist, and defects remedied at least twice a year.[2] Bad teeth, by interfering with proper chewing, are at times the cause of dyspeptic ailments. They also change the voice and foul the breath. Decay of teeth may not only cause toothache, but an excruciating pain in the side of the face and head (*i.e.* neuralgia) may result from an extension of the irri-

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[1] From the Latin *molaris*, "a grindstone."

[2] The temporary teeth in children should not decay, but should fall out clean and white when their function is ended. If not cared for, they are more likely to decay than permanent teeth, on account of the larger amount of animal matter they contain. Cavities in the temporary as well as in the permanent teeth should be filled, when possible. The premature extraction of a tooth may destroy the symmetry of the jaws, and allow the opposing tooth to grow to an uncomfortable length. In rabbits a tooth thus deprived of its opposing one grows like a tusk. Much can be accomplished by competent dentists toward regulating the direction of the teeth and the shape of the jaws. The excess of animal matter in the osseous tissue of young children accounts for the deformed upper jaws, with the projecting front teeth, which sometimes result from long-continued thumb-sucking.

tation from the small nerves in the tooth pulp to the large nerves of the face and head.

Fig. 58. (WHITE.)
The Connection of the Nerves of the Teeth with the Sensitive Nerves of the Face and Head.

Teeth to be strong must be used (*a*). Persons who eat mainly soft food (bread without crust, for example) are likely to have soft teeth. Teeth, as well as bones, require a certain proportion of mineral matter, which is supplied by such food as milk, eggs, cereals, and meat. They should be kept clean by frequent rinsing with water, and

by the use of a tooth-brush, especially upon the inner side of the teeth, in the morning and before retiring. As a dentifrice upon the moistened brush, prepared chalk, chalk and orris root, common salt, or a good soap may be used to advantage. Acid or gritty powders, or mixtures containing charcoal, are to be avoided. Every particle of foreign matter should be removed from between the teeth by a quill or wooden toothpick, or by drawing a thread of dental floss silk between the teeth.[1] This is important, as the mouth is a warm, moist cavity, favorable to the decomposition of food retained in it, and to the development of acids that tend to dissolve the lime salts of the teeth. If a softened spot appears in a tooth, the bacteria of the mouth attack the dentine, and decay sets in.[2]

125. The Salivary Glands. — The saliva is secreted by three pairs of glands, the *parotid*, the *submaxillary*, and the *sublingual*, and by the general mucous surface of the mouth. The parotids,[3] one just in front of and below each ear, open into the mouth by ducts opposite each second upper molar tooth. The submaxillary glands,

[1] Pins, knife blades, and other metallic substances should never be used as toothpicks, for they are likely to injure the enamel.

[2] To prevent acidity, a mouth wash of bicarbonate of soda or lime water may be used occasionally with good effect. To remove odors, a solution of common salt, or a wash of five drops of carbolic acid, one quarter teaspoonful of listerine, and one teaspoonful of glycerine in a half tumbler of water, is serviceable. Acid medicines should always be taken, diluted with water, through a glass tube, and the mouth thoroughly rinsed afterward with water.

[3] Called *parotid*, from two Greek words, meaning "near the ear." These glands are sometimes called masticatory glands, as they are found only in animals furnished with grinding or masticating teeth. The disease known as *mumps* is an inflammation of one or both of these glands.

beneath the floor of the mouth and just within the angles of the lower jaw, open by a common duct, under the tongue, at its junction in front with the floor of the mouth. The sublingual glands lie under the tongue, and discharge their secretion by ducts near the opening of the canal from the submaxillary glands.

Fig. 59.

Diagram showing the location and relations of the salivary glands of the left side, a large part of the lower jaw being removed.

T, the tongue. SLG, the sublingual gland.
LJ, part of the lower jaw. SMG, the submaxillary gland.
PG, the parotid gland.

126. The Pancreas is a fleshy gland, about six inches in length, lying transversely behind the stomach and large intestine. It secretes the *pancreatic juice*, a digestive fluid which is poured into the upper part of the small intestine.

127. The Liver is the largest gland in the body, weighing in the healthy adult from three to four pounds, and measuring in its transverse diameter from ten to twelve inches. It is of a dark brown color, is situated in the upper part and right side of the abdomen, and receives all the blood from the stomach and intestines through the portal vein. Part of the nitrogenous digested materials received in this way is probably converted by the liver cells into serum albumin. This is carried into the blood current from the liver, and is distributed throughout the body by veins known as *hepatic* veins, which connect with a large vein (the *inferior vena cava*) that empties into the heart. An excess of these nitrogenous materials, together

with substances brought by the return blood current to the liver, is converted by the liver cells into urea. These cells also break down old red blood corpuscles, returning any useful residue to the blood.

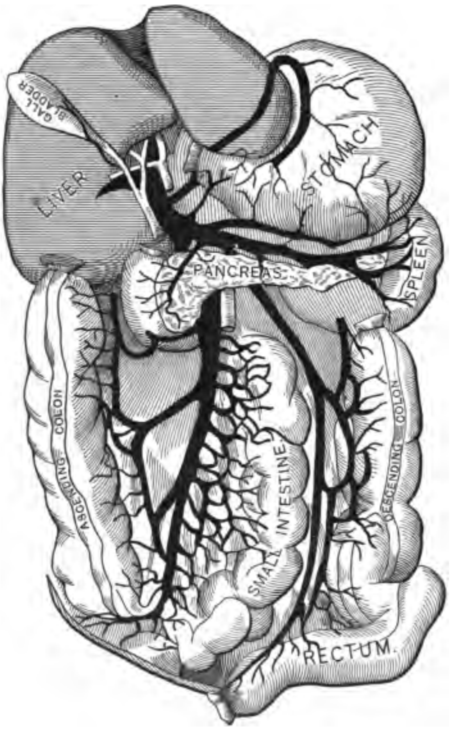

Fig. 60.
The Portal Vein and its Branches.

The liver has still other functions. Some of the sugar which it receives by the portal vein is taken out of the blood by the liver cells and stored up in the liver as *glycogen*, to be given out as sugar, in the intervals of digestion, whenever the blood of the body needs it.

The liver also secretes *bile*, one of the digestive fluids. Its flow is constant, but increases soon after digestion in the stomach begins. Part of it, in the intervals of digestion, is stored up for future use in the *gall-bladder* — a pear-shaped bag attached to the under surface of the liver. Bile, when secreted, is carried by a multitude of fine canals within the substance of the liver into a main tube, which opens, together with one

from the gall-bladder, into a larger tube known as the *common bile duct*, which is joined farther on by the pancreatic duct. Both the bile and pancreatic juice are then discharged by a common opening into the upper part of the small intestine.

128. The Various Steps of Digestion. — Mastication. — "The amphibian bolts its fly, the bird its grain, and the fish its brother, without the ceremony of chewing," but in man, *mastication* is necessary for complete and comfortable digestion. When food has been received into the mouth and cut and torn into pieces by the incisors and other teeth, it is then chewed or ground into minute fragments. For this purpose, by the action of the tongue, lips, and cheeks, it is rolled about the mouth and placed between the lateral teeth, especially the molars.

The teeth of the human being combine the characteristics of those of the carnivora and herbivora, — that is to say, are adapted for masticating both animal and vegetable food. The first appearance of teeth indicates that other food than milk can now be used, while the cutting of the permanent teeth shows that food which requires much chewing is to be included in a proper diet.

129. Insalivation. — At the same time that food is being chewed, it is softened by *insalivation*, or a thorough mixture with the saliva, so that it can be easily swallowed and readily acted upon by the digestive fluids farther on in the alimentary canal. Sapid substances, such as sugar and salt, are also dissolved so that they can be tasted. Part of the cooked starch [1] in the food is changed

[1] The firm envelopes of unbroken raw starch granules prevent the contents of the starch cells from being readily acted upon by saliva.

into dextrin and then into maltose, a soluble form of sugar, by the ferment action of the *ptyalin* of the saliva. Saliva acts best in an alkaline medium, but when swallowed continues to act upon cooked starch for a short time in the acid secretion of the stomach. The conversion of starch is resumed with activity in the small intestine, under the influence of the alkaline secretion of the pancreas.

130. The Saliva is a thin alkaline fluid. Besides its softening and transforming properties, it keeps the mouth moist, to enable us to speak with comfort. From one to three pints are secreted per day in a man of average size, the quantity increasing with the hardness and dryness of food. It is also increased by the movements of the lower jaw in mastication, by anything introduced into the mouth, and especially by those things which stimulate the nerve of taste. Its flow is largely under the influence of the nervous system. The mere thought or smell of agreeable food will "make the mouth water," while under the influence of anger or fear, the tongue, in its dryness, is said to "cleave to the roof of the mouth."

131. Deglutition. — The food, having been properly prepared, is moved toward the pharynx to be swallowed. The final steps in *deglutition* are involuntary. As the food or drink enters the pharynx, it is grasped by the constrictor muscles and hurried on into the oesophagus, — the openings leading to the lungs, nasal cavities, and ears being usually protected from its ingress by the approximation of their walls and by the raising of the soft palate. If the mechanism of swallowing is disturbed by excessive laughing or talking or by rapid swallowing, food, especially the fluid portion, is likely to enter the larynx or nose,

and cause coughing, sneezing, and sometimes serious results unless prompt aid be furnished.[1]

The passage of food or drink to the stomach is effected by means of the peristaltic action of the oesophagus. This action is at times sufficiently powerful to overcome the laws of gravitation. Hence, liquids and solids may, by some persons, be swallowed in any position of the body, even standing on the head, as is done by jugglers.

132. Stomach Digestion.—Just as soon as the food reaches the stomach, *stomach digestion* begins. The mucous membrane, which in the intervals of digestion is of a pale red color, now becomes bright red from its engorgement with blood. Its folds are obliterated, the pyloric sphincter closes the opening into the intestine, the muscles in the walls of the stomach begin to churn its contents and to mix them with the gastric juice, which is now abundantly poured out.

133. The Gastric Juice is a thin fluid, strongly acid. It dissolves certain mineral salts found in the cereals and other food substances, dissolves the connective tissue of meat, releases fat from its envelopes by breaking them up, and transforms some of the proteids, or albuminous material,—such as lean meat, the gluten of wheat, and white of eggs,—into *peptones*, in which form they are liquefied and made capable of absorption. This transformation is effected by the ferment action of an ingredient of the gastric juice known as *pepsin*,[2] assisted by an acid ingredient

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[1] Sometimes, for example, particles of meat, going the "wrong way," lodge in the larynx and cause death by suffocation. (See Emergencies, p. 399.)

[2] Pepsin, obtained generally from the stomachs of pigs, is used as an artificial digestant in certain forms of dyspepsia.

(free hydrochloric acid). It contains also another ferment, *rennin*,[1] which curdles milk.

Much gastric juice is secreted in 24 hours; probably the amount is more than five times that of the saliva. Its quantity is increased by stimulating substances, like mustard and catsup, in contact with the mucous membrane of the stomach, and its flow is facilitated by the odor and appearance of appetizing food. On the other hand, the quantity is diminished by fear, anger, anxiety, or grief, and also by excessive eating and drinking.

134. While stomach digestion is going on, the fluid portion of the food — both that which has entered the stomach as fluid and that which has been liquefied in this organ — is rapidly taken up by the absorbents of the stomach and carried into the blood.

The unabsorbed food begins slowly to leave the stomach about half an hour after its introduction, the pylorus relaxing, at intervals, to allow it to pass out[2] in the form of a thick, cream-like fluid, called *chyme*. This is a mixture of some of the sugar and salts of the food, transformed starch or maltose, softened starch, water, mucus, broken fat and connective tissue, peptones, and of much undigested material if the meal has been too hearty.

The entire digestion of an ordinary meal in the stomach usually requires from two to four hours. Some foods are thoroughly digested, so far as the stomach is concerned, in one hour, and some require as much as five

[1] Milk is promptly curdled in the stomach, but most of it is redissolved later, unless the quantity of milk has been more than can be digested.

[2] Substances more or less indigestible are acted upon with difficulty. Sometimes they are thrown up, or pass, after many hours, into the small intestine, causing suffering (colic).

hours (*a*). The duration of stomach digestion varies also in different persons, and in the same persons at different periods. It depends not only upon the kind and quantity of food taken, but also upon the condition of the nervous system and the amount of exercise.

135. Intestinal Digestion. — The acid chyme, upon entering the intestine, comes in contact with the pancreatic juice, bile, and intestinal juice, all of which are alkaline in reaction, and is changed by them into a thin, milky, alkaline fluid, the *chyle*. The liquefaction and transformation of proteids into peptones, begun by the stomach, is continued by the pancreatic juice, assisted, probably, by the intestinal juice. The transformation of cooked starch into maltose, begun by the saliva, is continued by the pancreatic juice, which also acts upon some of the raw starch. Of the fats, a part is saponified; and a part, by the combined action of the bile and the pancreatic juice, is changed into an emulsion, to be absorbed by the intestinal villi. *All this is intestinal digestion.*[1]

136. The Pancreatic Juice[2] is a clear, viscid fluid, resembling saliva. It has three ferments: *trypsin*, *amylopsin*, and *steapsin*.[3] Trypsin acts like pepsin on proteids, changing them into peptones; but, unlike pepsin, it can act in an alkaline medium, as well as in a slightly acid one, and can split peptones into other nitrogenous substances. Amylopsin changes starch into sugar, and acts on raw as well as on cooked starch. Steapsin splits part

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[1] The passage of the food through the small intestine is said to occupy, on the average, about twelve hours.

[2] "Pancreatine," obtained from the pancreas of animals, is much used as an artificial digestant.

[3] It is said to have also a milk-curdling ferment, practically not used.

of the fats into glycerine and fatty acids. The acids unite with the alkalies of the pancreatic juice and the bile, to form soaps, which aid in emulsifying the fat not split into glycerine and fatty acids.

137. **The Bile** is of a color varying from green to a golden yellow. About two and a half pints are secreted in twenty-four hours. The principal action of the bile is to assist the pancreatic juice to emulsify fat. Probably it prevents the decomposition and putrefaction of food during its passage through the intestines, and perhaps increases the muscular action of the intestines and lessens constipation. Part of the bile is thrown off as an excretion, and part of it is reabsorbed by the portal vein, to be again secreted. If the bile is not secreted, or is prevented from entering the small intestine, an animal will become very feeble and emaciated, and may die.[1]

138. **The Intestinal Juice** is a thin, yellowish secretion, from the glands of the intestines. It plays a subordinate part in digestion, but its action is not thoroughly understood. It may aid, by its alkalinity, in the emulsification of fat and the transformation of proteids. It may change some of the maltose into dextrose, another form of soluble sugar. It has but little action on starch.

139. **Absorption** is the process by which liquefied and transformed food is taken up by the venous capillaries and lacteals and carried into the blood. By the blood it is conveyed to the heart, and from the heart it is distributed to every part of the body by means of *the circulation*. Then *assimilation* occurs.

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[1] Biliousness is not due to an excess of bile, but to deranged secretion or action of it.

As the entire mucous membrane of the alimentary canal is well supplied with blood-vessels and lymph-vessels, it is probable that, in a small degree, absorption of water, common salt, and sugar occurs in the mouth, pharynx, and oesophagus. While there is some absorption from the stomach, it mostly occurs in the small intestine, with its immense surface and innumerable villi. Here much of the sugar and peptone and most of the fat are absorbed.

The lining cells of the alimentary canal have a selecting power not understood. This is aided by the pushing action of the intestine, and by the process of *osmosis*, — *i.e.* the interchange of liquids (or gases), separated from each other by a moist animal membrane, which has no visible pores. The digested materials are soaked up by the membrane in a manner similar to the action of blotting paper.

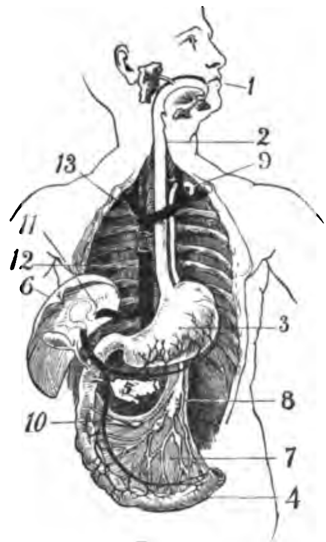

Fig. 61.

A Diagrammatic Representation of the Various Organs concerned in the Conversion of Food into Blood.

1, mouth and salivary glands.
2, the oesophagus. 3, the stomach.
4, a portion of the small intestine.
5, the pancreas. 6, the liver.
7, mesentery with lacteals.
8, receptacle of chyle.
9, the thoracic duct emptying its contents into the left subclavian vein.
10, branches of portal vein leading to liver.
11, an hepatic vein leading from the liver to the large ascending vein.
12, the large ascending vein cut off at its junction with the heart.
13, the large descending vein cut off in like manner.

140. Emulsified fats are absorbed by the epithelial cells of the villi, from which they find their way into the lacteals, and thence to the thoracic duct and the heart.

Water, salts, and sugars pass into the rootlets of the portal vein, and thence to the heart. The peptones are taken up by both lacteals and blood-vessels. In the large intestine, water and soluble salts are the main substances absorbed, though artificially prepared food introduced into the rectum may be absorbed to a limited extent, and maintain life for a few weeks.

141. The Fate of Absorbed Food. — Water, sugars, and some salts are ready for absorption when taken into the body. Indiffusible carbohydrates, like starch and dextrin, are changed by digestion into diffusible sugar, and indiffusible proteids into diffusible peptones. Fats, for the most part, are mechanically altered. Diffusible peptones in the blood current are changed into non-diffusible proteids, serum albumin, and serum globulin, which are used to build up the albuminous tissues, the waste of which is discharged from the body as urea, creatinin, etc. The fat disappears soon after entering the blood. Some of it is stored up as the fat of the body, but probably the greater part of it is changed into water and carbon dioxide, evolving, in the process, heat or other forms of energy. The proteids of the body are formed only from the proteids of food, but fat can be formed from both the proteids and carbohydrates of food. Probably most of the sugar absorbed is destroyed in the active tissues of the body, especially the muscles, and eliminated as carbon dioxide and water. A small part is changed into fat, while considerable (especially after a hearty meal) is stored in the liver as glycogen, and, when needed, given to the blood as sugar in the intervals of digestion.[1] Water and the min-

[1] When the sugar in the body cannot be utilized by the tissues, part of it is excreted by the lungs and kidneys, causing a condition known as diabetes.

eral ingredients of food, as a rule, pass through the system unchanged, affording necessary fluidity, strength, or alkalinity to various tissues and fluids.

142. In healthy digestion the food which cannot be assimilated or converted into heat, energy, and strength is ordinarily eliminated with ease by the excretory organs. But if the bodily powers be overtaxed by food inappropriate as to quantity or quality, the extra eliminating work demanded, especially of the kidneys and liver, may seriously derange these organs.

143. Requisites for Normal Digestion.—In order to do their work, the digestive organs must be normal in structure and capable of the necessary muscular movements. Their secretions must be perfect as to quality and quantity. Gastric juice, for example, will not act as a solvent if its acid is neutralized by an alkali. Nor will the pancreatic and intestinal juices perform their functions if their alkaline nature is destroyed by acids.[1]

The food also must be just sufficient, and so cooked or otherwise prepared that it can be acted upon with ease by the digestive organs and their secretions. It must be taken at regular intervals, thoroughly chewed, and slowly swallowed. It should not be taken immediately before or after great physical or mental effort. Broken or decayed teeth, or a defective number of them, sore mouth or throat, neuralgia of the face, the waste of saliva by the habit of expectoration, torpidity of the muscles of the alimentary canal, defective action of the glands concerned in digestion, impediments in ducts, and undue

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[1] The lesson of moderation in the use of alkalies and acids is evident.

anxiety of mind, all interfere with proper digestion and nutrition.[1]

144. Effects of Alcohol and Narcotics upon the Digestive Organs and Digestion. — Alcohol, taken in small quantity, produces a feeling of warmth in the stomach, accelerates its muscular action, and increases the functional activity of the other digestive organs. When it aids digestion it is "probably not through any inherent powers of its own, but by virtue of its irritant properties, inducing an increased flow of gastric juice." Larger amounts interfere with the digestive process, partly by rendering the albuminoids less soluble, and partly by producing, as a secondary effect, constriction of the minute blood-vessels, thus causing a decrease in the digestive secretions. Frequently, people who call themselves moderate drinkers, and who are never intoxicated, suffer from an obstinate dyspepsia, loss of appetite, and nausea, especially in the morning. To allay these uncomfortable sensations, they resort to an early alcoholic drink, which only increases the trouble.

When alcohol is taken in still larger amount and used frequently, the stomach becomes inflamed, hardened, and contracted. The liver is frequently altered in shape, becoming either contracted (*i.e.* fibroid degeneration, causing cirrhosis or "hobnail" liver), or enlarged from fatty degeneration, causing "fatty liver." When the liver is contracted, the vessels leading to that organ are compressed, and congestion of the stomach, rectum, pharynx, oesophagus, and face is likely to result, while indirectly the functions of the heart and kidneys are disturbed. These changes in the digestive organs of course interfere with

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[1] Difficult digestion, or "dyspepsia," demands, therefore, a careful study of the causes in each case, before medicinal measures are used.

their functions; food is not properly digested, the blood is poor, and the liver fails to excrete the wastes that come to it and that originate in it.

145. *Tobacco*, *opium*, etc., while acting mainly on the nervous system, frequently produce loss of appetite, nausea, and a persistent dyspepsia, by deranging the gastric juice.

QUESTIONS.

1. What is meant by nutrition?
2. What are the wastes of the body, and how are they disposed of?
3. What is digestion, and what are the digestive organs?
4. Describe the alimentary canal, and name its different portions.
5. What begins the alimentary canal, and what is there secreted?
6. Describe the pharynx, and state what opens into it.
7. What are the constrictors of the pharynx, and their object?
8. Describe the oesophagus, its object, and mode of action.
9. Describe the stomach and its openings.
10. How are the intestines divided? Describe the small intestine.
11. What is the mesentery, and its use?
12. How is the movement of the food in the intestine effected?
13. What is the mucous membrane of the intestine?
14. Describe the lacteals.
15. What secretions enter the intestine near the pylorus, and from what?
16. Describe the large intestine, the coecum and its appendage.
17. What are the accessory organs of digestion?
18. Describe the teeth, and their uses.
19. What do human teeth indicate as to the proper food of man?
20. Why should care be taken of the temporary or first set of teeth?
21. How should teeth be preserved?
22. Describe the salivary glands, and their secretion.
23. Describe the pancreas and its secretion.
24. Describe the liver and state its functions.
25. What is the process of the conversion of food into tissue?

26. What is the chyme? The chyle?
27. How are the fatty matters in food converted into an emulsion?
28. What is absorption, and where does it occur?
29. How do the absorbed products of digestion reach the general circulation?
30. What changes are effected after they have reached the blood?
31. What is assimilation?
32. What is necessary to healthy digestion?
33. What are the effects of alcohol on digestion and the digestive organs?
34. What are the effects of tobacco, opium, etc.?

CHAPTER X.

THE CIRCULATION.—BLOOD.—LYMPH.

146. The Organs of Circulation. — The blood, as we have seen, is the form which the nutritive constituents of food take after digestion. It flows as pure blood in one set of currents from the heart to the tissues for their nourishment, and returns in another set of currents to the heart, laden with waste products, which are expelled from the body through the lungs and other excretory organs. This flow of the blood to and from the various parts of the body is *the circulation*, and the organs through which it is propelled are the *organs of circulation.* These organs are the heart and the blood-vessels, the latter consisting of the arteries, capillaries, and veins. There is in reality only one circulation, but the heart sends out two streams of blood: one to the lungs, which returns again to the heart, sometimes called the *pulmonary*, *respiratory*, or *lesser*, circulation; the other through the rest of the body and back to the heart, called the *systemic*, or *greater*, circulation.

147. The Heart is a hollow, muscular, conical-shaped organ, in adults about five inches long. It is situated obliquely in the chest, between the two lungs, and behind the lower two-thirds of the breast bone, its posterior portion in part resting upon the diaphragm. It is chiefly on the left side of the body. Its tip, or apex, is directed forward and downward, striking against the walls of the thorax, between the fifth and sixth ribs, a little to the left

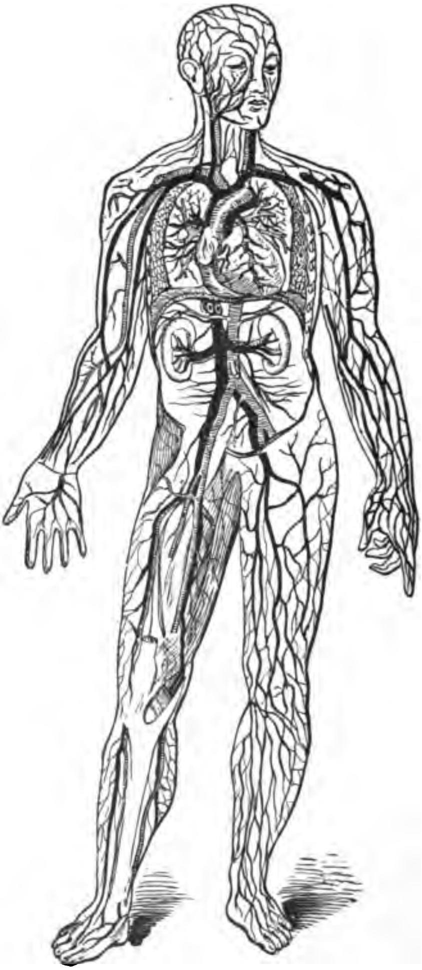

Fig. 62.

Front View of the Organs of Circulation. — Veins, black; arteries, with transverse lines. Parts on the right side of figure are removed to show some of the deep vessels, while the left side shows superficial vessels.

of the breast bone, at which point we can usually best feel the impulse of the organ. Its broad attached end,

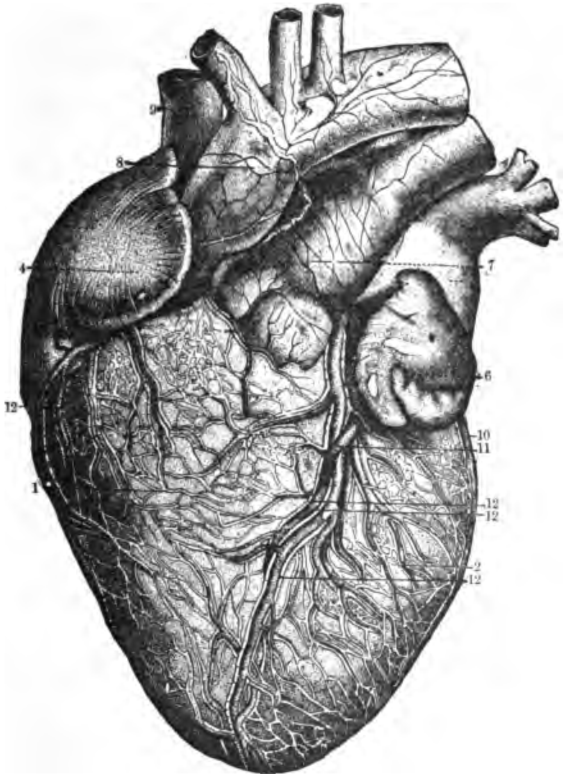

Fig. 63.

Heart, Front View.

1, right ventricle.
2, left ventricle.
4, right auricle.
6, left auricle.
7, pulmonary artery.
8, the aorta.
9, superior vena cava.
10 and 11, front coronary artery and vein which in part control the blood-supply of the substance of the heart.
12, lymphatic vessels.

or base, is directed upwards and backwards and to the right. Owing to its surroundings, this end of the heart has comparatively little motion.

148. The whole organ, with about two inches of the great blood-vessels which arise from it, is enveloped in a fibrous sac known as the *pericardium*.[1] This sac is lined with a smooth, glistening membrane, which secretes a lubricating fluid called *serum*, thus permitting the heart to move freely and without friction. The interior of the heart is also lined with a smooth, serous membrane, called the *endocardium*,[2] which is similar to and continuous with the lining membrane of the blood-vessels.

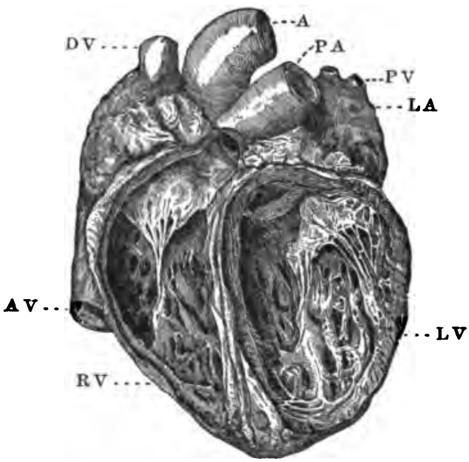

Fig. 64.

The Heart and Some of its Vessels. The ventricles are laid open to show their structure. The relative thickness of the walls of the ventricles are shown, also the muscle columns and their tendons, together with the curtain-like valves.

A, aorta.
P A, pulmonary artery.
P V, pulmonary veins of left auricle.
R V, right ventricle.
L A, left auricle.
D V, descending vein, or superior vena cava.
A V, ascending vein, or inferior vena cava.
L V, left ventricle.

149. Component Parts of the Heart.—The heart is divided by muscular walls into four compartments or cavities, the

[1] Derived from the Greek, signifying "around the heart."

[2] Derived from the Greek, signifying "within the heart."

two upper ones called *auricles*,[1] and the two lower, *ventricles*.[2] Into the auricle on the right side of the heart—*i.e.* the right auricle—open small veins, which take the venous or impure blood from the substance of the heart, and also two large veins,[3] one of which brings the same kind of blood from the upper half of the body, the other, that from the lower half. Into the auricle on the left side of the heart—*i.e.* the left auricle—four *pulmonary veins* open (two from each lung), bringing blood that has been purified in the lungs. When the auricles are full of blood, they contract simultaneously and force it into their respective ventricles, through openings (one between each auricle and its ventricle) that are known as the *auriculo-ventricular* openings. From the right ventricle arises the *pulmonary* artery, which carries venous blood to the lungs to be purified. From the left ventricle arises the *aorta*, which carries pure blood to all parts of the body. When the ventricles are full, they contract simultaneously and expel the blood into these arteries.

The openings between the auricles and ventricles, and those between the ventricles and the arteries which connect with them, are guarded by little doors or valves, composed of delicate but strong fibrous tissue. These open to allow the blood to pass onward in its natural course, and then close, thus preventing the blood from regurgitating, *i.e.* flowing back. The cavities of the left side of the heart are respectively smaller than those of the right, but their walls are stronger. Especially is this true

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[1] From the Latin, meaning "little ears," so called, it is said, from their resemblance to dogs' ears.

[2] Literally, the diminutive of stomach.

[3] Called the *superior* and *inferior vena cavae*.

of the left ventricle, whose function it is to send blood through the entire body (Fig. 64).[1]

150. **The Valves of the Heart** are arranged as follows: the *mitral*[2] valve, between the left auricle and left ventricle, is composed of two curtains, or flaps; and the *tricuspid*,[3] between the right auricle and right ventricle, of three flaps. These curtains in each opening are attached on one side to the margin of the opening, and hang suspended in the ventricles when blood is passing into these cavities. To their free edges are fastened delicate but strong tendons (*chordae tendineae*), which are attached to muscular prolongations from the inside of the walls of the ventricles, known as *papillary muscles.* The alternate contraction and relaxation of these muscles, assisted by the action of other muscle fibres in the ventricles, open and close the valves. When the ventricles are filled with blood, these muscles relax, and the free edges of the curtains come together.

The three valves at the beginning of the pulmonary artery and of the aorta, known as *semilunar* valves, are crescent-shaped pouches attached to the margins of the openings. When blood is forced from the ventricles by their muscular walls, these valves are pushed against the sides of the arteries named, but immediately afterwards they come together. The closure is effected by the contraction of the muscular fibres in the walls of the vessels, and by the backward pressure of the blood current.

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[1] Sometimes the heart is considered as a double organ; the right side, transmitting venous blood, is spoken of as the right heart, and the left side, transmitting arterial blood, as the left heart.

[2] From a supposed resemblance, when it is open, to a bishop's mitre.

[3] Having three points.

151. Action of the Heart.—The heart acts like a force pump, and is the principal instrument by which the blood is kept moving through the blood-vessels. Its muscular walls are well adapted for this persistent and difficult work, the fibres being strong and interlaced. The auricles have two layers of fibres, and the ventricles, which do much harder work, have several layers, one of them spiral.[1] When the auricles have emptied themselves, they relax, and again fill with blood. The contraction of the ventricles begins toward the end of the contraction of the auricles, the auriculo-ventricular valves closing and the semilunar valves opening. When the blood is discharged from the ventricles, they relax and the semilunar valves close. The contraction of the ventricles follows so closely that of the auricles, and is so much more pronounced, that the whole heart seems to contract at one time.[2]

152. The alternate contractions and relaxations of the auricles and ventricles cause the heart to roll somewhat, and to elongate, pushing its apex against the chest wall. These movements constitute the *pulsations*, or throbbing, of the heart. They are so constant that the organ seems never to have rest; but the alternate periods of relaxation, short as they are, afford in the aggregate considerable rest to the busy muscles of the heart.

The contraction of the muscles, especially those of the ventricles, and the closure of the valves of the heart give rise to what are known as *heart sounds*, which can be heard by placing one's ear over the heart of another and

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[1] The valves, vessels, walls, and internal muscles may be studied in a beef's heart. In a boiled heart, the muscles of the walls can be separated.

[2] The contraction of the heart is known as its *systole*, the relaxation as its *diastole*.

in contact with the chest, or by means of an instrument called the stethoscope. These sounds are termed the first and second sounds, and changes in their rhythm, intensity, or pitch are indications to the physician of the character of any disturbance or disease in the heart.[1]

153. Nervous Control of the Heart.—The steady, rhythmical pulsations are controlled by a nervous mechanism within the heart. In addition, the action of the heart is regulated to the varying needs of the body, by one set of nerves that originate in the brain and by another from the spinal cord, which decrease or increase the pulsations, as may be necessary. Influences which operate upon the nervous system operate also upon the heart. Its movements are decreased in frequency by sorrow or depression of spirits, and quickened by mental excitement, joy, or anger; hence the expressions, "one can hear his heart beat," or "his heart is in his throat," or "it beats like a trip-hammer." The temperature of the surrounding atmosphere, the quantity of food eaten, the age, sex, and muscular activity also affect the rapidity of the heart's action.[2]

154. Heart Beats.—At birth the number of beats is normally about 140 per minute, at the end of the first year 120, at the end of the second year 110; during middle

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[1] Normally, these sounds are nearly on the same key, and resemble the syllables *lŭb dŭp*.

[2] Functional derangement of the heart, causing pain and violent palpitations, may readily occur by repeated nervous excitement in feeble persons or those who, though physically strong, lack self-control. The heart is sometimes strained and injured in some one or more of its structures by excessive muscular exercise, especially in rowing, bicycle riding, prolonged marches, and fighting. Its action is sometimes enfeebled by the deposit of fat in its walls, as the result of a sedentary life or the repeated over-indulgence in alcoholics or fat-making foods.

life it varies from 70 to 80, being about 10 more in women than men, and in old age is about 60.

The normal frequency of the heart's action varies with the temperament, family tendency, and mode of living of the individual. Of Napoleon I. and the Duke of Wellington it is said the pulsations were but 40 per minute. In some persons, especially those with excitable, nervous temperaments, they number 90 or even more. Very rapid action tends to exhaust the heart; yet the vitality of the organ is remarkable. In man and other warm-blooded animals it is the last organ to cease giving signs of life, and even when it has ceased to beat, electricity has again aroused its action.[1] In cold-blooded animals, such as the frog and snake, whose heart-action is comparatively slow, the heart will continue to throb after the animal has been beheaded, and even after the heart itself has been removed from the body.

155. The Arteries[2] are a series of cylindrical, firm, but elastic canals, which commence with the aorta, and by divisions and subdivisions convey the blood to all the vascular parts of the body.[3] The larger arteries are com-

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[1] The ancients regarded various organs of the body as seats of the emotions. The spleen was the seat of anger and melancholy, hence the term "splenetic"; while the heart was the seat of joy, love, harmony, and the like. The words "courage," "cordiality," "heart-felt," "hearty" "heartiness," etc., have their derivation in this idea.

[2] So named from two Greek words, meaning "receptacle of air," since the ancients believed that these blood-vessels contained air only, — probably because they generally found them empty in the dead body. Arteries do not collapse when cut, as veins do. A firm tube of rubber will give a fair idea of what an artery is; while a tube with thin, flexible walls represents a vein.

[3] Arteries are found in every tissue except the hair, nails, epidermis, cartilages, and the cornea of the eye. But blood reaches the cells of these tissues by a peculiar process of absorption known as imbibition, or "drinking in."

posed of three coats: first, a smooth, delicate, and slightly elastic inner wall, similar to, and continuous with, the endocardium and the lining of the veins and the capillaries; next, a middle coat, composed of elastic and muscular tissue; and lastly, a very strong outer coat, composed of fibrous and elastic tissue with some muscular fibres.[1] As the arteries become smaller, the external coat disappears; hence the very small arteries (arterioles) have but two coats. In the capillaries (which connect the smaller arteries with the rootlets of the veins) the middle coat also disappears, and the thin, delicate, circular wall that remains is well adapted for the transudation of gases and fluids.[2]

Fig. 65.

A Part of an Artery. Enveloping it are lymphatics and lymphatic glands.

The *smoothness of the lining wall* prevents friction. The *elasticity* of the arteries permits them to yield without danger of bursting, as the blood is thrown into them with each stroke of the heart, and also enables them to accommodate themselves to the various movements of the body.

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[1] The outer coat is so strong that when a surgeon ties (ligatures) an artery, it is not broken. The two broken internal coats arrest and clot the blood and stop bleeding. Very seldom does a healthy artery rupture from the force of the blood current. The walls of the arteries are nourished by blood conveyed to them by little arteries called *vasa vasorum*. Corresponding vessels also supply the heart. The elasticity of the larger arteries will be best appreciated in the aorta of an ox or sheep. Like a piece of india-rubber, it yields when stretched, and immediately thereafter recovers itself.

[2] If a large artery is ligatured, the small arteries which connect the portion of the artery below the ligature with that above, or with another artery, become enlarged and establish a *collateral circulation*.

Their *contractility* affords them the power of adapting themselves to the variable quantities of blood which they contain, and which must be supplied to the tissues as required. As the blood is sent into the large arteries from the heart, the flow is intermittent. The caliber of the arteries, as they divide and subdivide, becomes smaller and smaller. But in the aggregate that caliber is greatly increased, and, owing to this and to their elasticity and contractility, the pulsations in the arteries are less intermittent as the arteries become smaller, and finally, in the capillaries, the blood current is uniform and constant, but slow. It thus becomes well adapted to furnish to each cell its appropriate nourishment, and to abstract from each its waste products.[1]

156. The Pulse.—With each beat of the heart, the arteries, already quite full of blood, are dilated by the additional blood sent into them. As the semilunar valves

Fig. 66.

Portions of Four Traces taken by the Sphygmograph, in Different Conditions of the Pulse.

close, the arteries contract to assist the onward flow of blood. The pulsations thus produced constitute the *pulse*, or wave, in the arteries. This is usually felt at

[1] The motion of the blood in the arteries may be illustrated by connecting a syringe, representing the left ventricle, with a large rubber tube, representing the aorta, which is connected with various tubes of gradually decreasing size, representing the subdividing arteries and the capillaries. The water is injected into the large tube in an intermittent and forcible current, which abates in the smaller tubes, and becomes continuous in the smallest.

the wrist, but may be felt over any artery which is located near the surface, as in the upper lip, the chin, temples, elbows, and inner side of the ankles. To determine the character of the pulse more accurately than by the sense of touch alone, an ingenious registering instrument, called the sphygmograph, may be attached to the forearm, and by means of a lever lightly resting on the pulse there will be registered with a pencil on prepared paper the character of the pulsations. The character of the pulse is a fair indication of the action and strength of the heart, and is modified or altered by the same causes that affect the action of the heart.[1]

157. The Capillaries are hair-like blood-vessels, which permeate the vascular organs in networks variously arranged, and bring the blood into close contact with the cells of the tissues, but none of them enter the cells.[2] Though very small tubes, their number is great. Through them the blood is propelled very slowly and gently. Its nutritious ingredients ooze through the walls of these vessels into the surrounding cells, and some of the waste material from the tissues finds its way into the capillaries in the same manner.[3] In the glandu-

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[1] Though the pulse generally averages a certain number of beats per minute (see § 154), it is increased or diminished at times by apparently slight causes, especially in young children. Thus, after crying, the pulse rises 10 to 20 beats, and is lowered the same amount during sleep. After a meal the pulse of an adult has from 5 to 10 beats more per minute than before; 5 beats more when sitting than when lying down; 10 beats more when standing than when sitting; and 10 to 50 more beats when in motion than when at rest.

[2] Capillaries are about $\frac{1}{3000}$ of an inch in diameter, and are composed of thin, flat cells, united at their edges.

[3] The irrigation system in use in the western part of the United States seems to be modelled after the plan of the capillary circulation. Large

lar organs the capillaries supply the substance requisite for secretion; in the villi of the intestine they take up the elements of the digested food; in the lungs they absorb oxygen and exhale carbon dioxide; in the kidneys they discharge waste products collected from other parts.

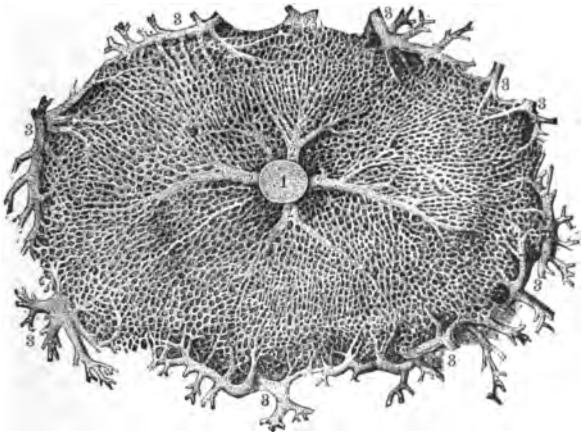

Fig. 67.

Injected Cross-section of a Lobule of the Liver, showing the capillary network between the portal and hepatic veins. Magnified 60 diameters.

1, section of *intra*-lobular vein. 2, its branches collecting blood from the capillaries. 3, *inter*-lobular branches of the portal vein connecting with the capillary network, and supplying the lobule with blood for its nourishment.

The capillary circulation thus furnishes, directly or indirectly, the materials for the growth and renovation of the entire body. This circulation is usually studied in a tissue which is transparent and vascular, such as the web

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ditches bring water from a reservoir into smaller ditches, and these into still smaller ones, which pass between the plants. The water in these very small ditches moves slowly, oozing into the soil and among the rootlets.

of a frog's foot, or of a bat's wing, and is an exceedingly beautiful and interesting sight.[1]

158. The capillaries, having very thin and somewhat elastic walls, vary in size, at different times, in response to any exciting cause. They are largest when the part to which they are distributed is functionally active.

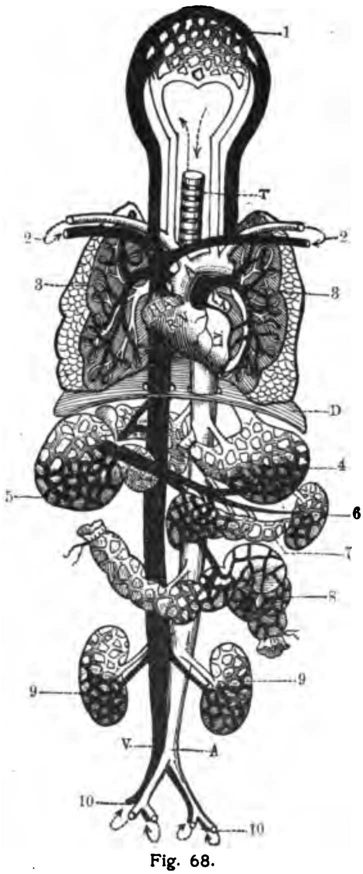

Fig. 68.

A Diagram of the Capillary Circulation, with arteries in white, veins in black.

T, trachea, arrows representing incoming and outgoing air.
D, the diaphragm.
A, artery (the aorta). V, vein.
1, capillary circulation of head.
2, vessels of upper extremities.
3, capillaries of the lungs.
4, of the stomach. 6, of the spleen.
5, of the liver. 7, of the pancreas.
8, of a portion of small intestine.
9, of the kidneys.
10, vessels of lower extremities.

[1] **"We see the great arterial rivers, in which the blood flows with wonderful rapidity, branching and subdividing until the circulating fluid is brought to the network of fine capillaries, where the corpuscles dart along one by one. The blood is then collected by the veins and carried in great currents to the heart. This exhibition to the student of Nature is of inexpressible grandeur; and our admiration is not diminished when we come to study the phenomena in detail. . . . It can be seen how the arterioles regulate the supply of blood to the tissues; how the blood distributes itself by the capillaries; and finally, having performed its office, how it is collected and carried off by the veins."** — FLINT, ***Text-book of Physiology.***

Emotion and exposure to warmth dilate the small arteries by relaxing their muscular fibres; and more blood at such times fills the capillaries in connection with them, so that the parts to which they are distributed "blush," or become ruddy. On the other hand, pallor is produced by continued cold, anger, or fear, which cause the muscles to contract and the amount of blood in the small arteries and capillaries to be diminished. So numerous are the capillaries that their entire capacity is said to be "from five hundred to eight hundred times that of the arteries." Their extensive distribution may be appreciated when we consider that the slightest cut upon any part of the skin or mucous membrane which is sufficient to induce bleeding must cut across many capillaries. They are most numerous wherever the nutritive processes are most active, as in the lungs and glands and in the mucous membrane of the small intestine, and, during the functional activity of these parts, may be said to bathe them in blood.[1]

159. The Veins.—After the blood has parted with nutriment to the tissues, and absorbed waste products from them, it passes on from the capillaries into larger channels, called small veins or veinlets, and then into still larger ones known as veins. Waste products not so taken up are carried into the blood by another set of vessels, called the lymphatics, described in § 169.

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[1] Blood carried to a part for a length of time, in larger quantity than is necessary for its nourishment, is liable to cause its inflammation and even its death. When the supply of blood is for a lengthened period much smaller than is demanded, failure in nutrition and death of the part may result; or, if a part has been long contracted, as by frost-bite, and blood is too suddenly brought into it, inflammation and death of the part may ensue.

Veins, like arteries, are composed of three coats, but they contain a smaller quantity of muscular and elastic fibres, and a larger proportion of firm connective tissue. They are consequently less elastic and contractile, and more compressible, though they have considerable capacity for resistance to pressure. They are also distinguished, in the limbs and in the external parts of the head and neck, by being provided with valves so arranged that their closure prevents a backward flow of blood. The position of these valves may be seen by the little prominences that appear in the course of the superficial veins, if we tie a cord around the wrist or arm.

Fig. 69.
A Part of a Vein, with its branches laid open, showing the valves.

The *capacity* of the venous system is greater than that of the arterial, owing to its numerous intercommunications. If an obstruction occurs in a vein, the blood can therefore be diverted into one or more branches more readily than in the case of the arteries; but the encircling of an entire limb with a tight band would obstruct the circulation in all the vessels of that region, and induce swelling below the band.[1]

160. The Circulation of the Blood.—The *movements of the blood* will probably be best understood if we follow it from point to point in its circuit.

In the first place, the venous or impure blood, collected

[1] Such is sometimes the effect of tight garters. Persons whose vocation necessitates much standing sometimes have "varicose veins," or knotted veins of the legs, due to impeded flow of blood through these vessels. In such cases, elastic stockings should be worn to support the vessels.

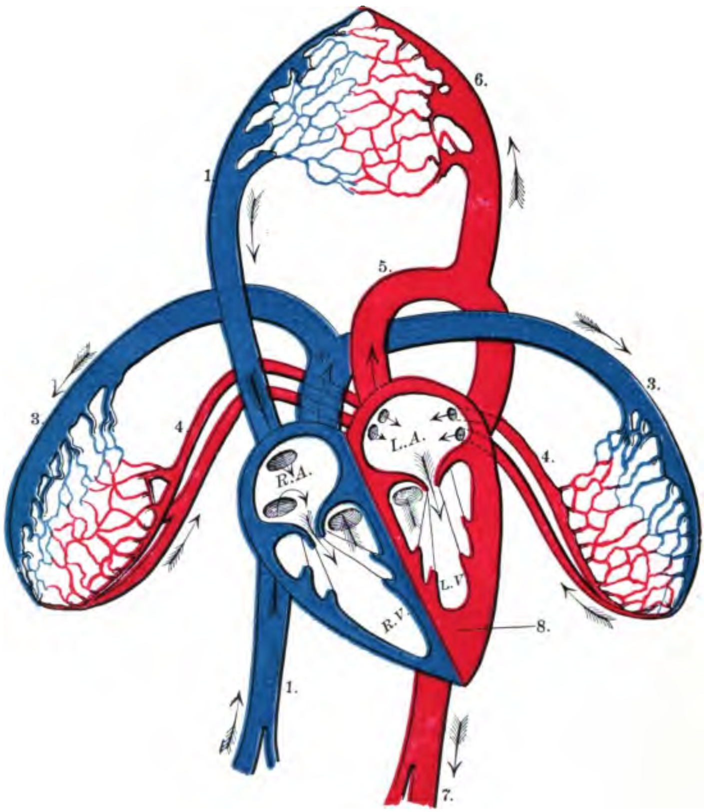

Fig. 70.

Diagrammatic Representation of the Circulation through the Heart and Body. Arrows show the direction of blood currents.

RA, right auricle.
LA, left auricle.
RV, right ventricle.
LV, left ventricle.
1, 1, superior and inferior vena-cavae.
2, pulmonary artery.
3, 3, branches of pulmonary artery.
4, 4, pulmonary veins.
5, arch of aorta.
6, branch to upper part of body.
7. branch to lower part of body.
8, heart.

by the smaller veins from the various parts of the body, is poured into two great veins, which open into the *right auricle.* When the auricle is dilated and filled to its normal limit, its walls contract and expel the blood through the right ventricular opening into the *right ventricle.* This ventricle, thus dilated and filled, contracts, and expels its contents through the *pulmonary artery* into the *lungs*, where the blood is thoroughly distributed among the air cells by numerous capillaries, and is purified by exchanging its waste products for the oxygen of the air. From the lungs it is carried as pure blood by the *pulmonary veins* into the *left auricle.* When this auricle is normally dilated and filled, it contracts, and the blood is forced through the left ventricular opening into the *left ventricle.* This ventricle, when dilated and filled, contracts, and sends the blood into the *aorta*, and through its branches to the capillaries for the nourishment of the tissues. Having parted with much of its life-giving principles and acquired the results of decay and disintegration in the tissues, the blood requires to be again purified, and commences, at the extremities or sources of the venous system, its return to the heart. Passing successively through the enlarging veins, as though it were a river system, with its springs, brooks, and rivulets, or like the rootlets enlarging into the roots of a tree, it finally again reaches the right auricle.[1]

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[1] From 1545 to 1586 several persons described portions of the circulatory apparatus and their function. In 1602 Harvey began his investigations upon living animals, and in 1616 discovered the circulation of the blood. His description of the movements of the heart is forcible, clear, and accurate. Of the heart, he says, "by an admirable adjustment all the internal surfaces are drawn together, as if with cords, and so is the charge of blood expelled with force." Like other investigators in the same field, Harvey was subjected to much persecution.

161. The *force and rapidity of the circulation* are very great, but differ widely in the various sets of vessels and in the different organs. The average time required for the passage of the blood from the heart to the tissues and back is about twenty seconds.[1] The flow into the arteries and through the capillaries is effected by the powerful contractions of the heart, aided by the contractility and elasticity of the arteries, and, in the case of the capillaries, also by the elasticity of the surrounding tissues. So great is the force exerted, that if a large artery be cut across, the blood spirts to a distance of several feet.

In health, both arteries and veins readily withstand the force of the circulation; but when weakened by age, injury, or disease, they may burst under unusual exertion, such as fast walking or running, the lifting of heavy weights, or even by a sudden change of position, as in the quick rising from a recumbent posture. If vessels of the brain give way, paralysis or death may occur from the pressure of the escaped blood upon the brain. This condition is known as apoplexy.

The flow of blood through the veins is more rapid than that through the capillaries, but considerably slower than the arterial current. It is effected by the pressure from the capillary circulation, by the contraction of the voluntary muscles through which the veins pass, and by the act of inspiration, whereby the chest is expanded. This expansion not only tends to draw air into the lungs, but also blood from the veins.[2]

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[1] Dalton estimates that the average rapidity of an arterial current is 12 inches per second, of a venous current 8 inches per second, and the rate through the capillaries is rather less than $\frac{1}{25}$ of an inch per second.

[2] If a vein, especially in the lower part of the neck, be wounded, and considerable air enters the blood, death is likely to result. "The air finds

162. The Blood is eminently the "vital fluid." If from any cause much blood is lost, great weakness follows, and if the flow is not checked, death results. On the other hand, if fresh blood from a living person or animal be injected into the veins of one much prostrated, or even apparently dead, especially if this condition be the result of loss of blood, he may be revived. This operation is known as the *transfusion of blood*.[1]

163. To the eye, the blood seems to be merely a homogeneous red, scarlet, or dark-blue liquid, according as it is drawn from the capillaries, arteries, or veins. Blood has a salty taste, and a very small quantity of it is capable of staining a large amount of water. As shown by a microscopic examination, it consists of two parts, the *plasma* and the *corpuscles*. The first is an alkaline, transparent, and nearly colorless fluid, in which the corpuscles swim in countless numbers.

164. Red Blood Corpuscles.—Blood corpuscles are of two kinds, the red and the white. The red are smaller than the white, and much more numerous.[2] The red color is

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its way to the right ventricle, is mixed with the blood in the form of minute bubbles, and is carried into the pulmonary artery; once in this vessel it is impossible for it to pass through the capillaries of the lungs, and death by suffocation is the inevitable result."—FLINT.

[1] The operation originated in the 17th century, and much was expected from its use, some believing that old people could be rejuvenated by using the blood of the young; but, after a number of deaths had resulted, it fell into disrepute. The operation has been revived, and, owing to improved surgical appliances and to a better knowledge of the subject, excellent results have been obtained. Warm milk of cows has been successfully used instead of blood.

[2] Red corpuscles are about $\frac{1}{3500}$ of an inch in diameter, and about $\frac{1}{13000}$ of an inch in thickness, while the white are about $\frac{1}{3000}$ of an inch in diameter.

due to the globules *en masse;* if viewed separately by transmitted light, they are of a light amber color. It has been estimated that there are five million red corpuscles in a minute drop (a cubic millimetre) of blood.[1] In form they are flattened, circular disks, slightly hollowed out on each side, and under the microscope are seen to arrange themselves in rows, adhering together side by side like a roll of coins. They are of jelly-like consistency, very elastic and extensile, easily bent and distorted, and can be pushed through the walls of the capillaries. They contain water, salts of phosphorus, and potassium, but their most important ingredient is a reddish proteid substance containing iron, which gives the color to blood. This substance, called *haemoglobin*, has a strong affinity for oxygen, and unites with it; but the tissues, which have a stronger affinity, absorb a large part of the oxygen in combination with the coloring matter, and replace it with carbon dioxide. This changes the color of the blood from red or scarlet (depending on the amount of oxygen present) to a dark blue. On account of the life-giving oxygen thus carried by the red globules, they are sometimes spoken of as "little boats laden with precious

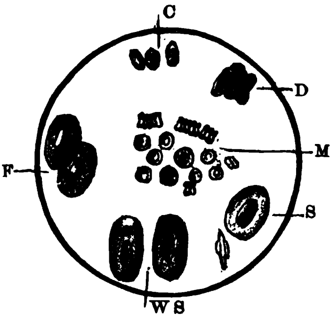

Fig. 71.

Blood Corpuscles.

M, of man. F, of the frog. WS, of the water salamander. S, of a shark. D, of the dove. C, of the camel.

[1] In persons who are very pale and have poor, thin blood, the number of red corpuscles is estimated to be one-third less than the normal amount, which is from 300 to 400 of the red to every white corpuscle.

freight," which are in health despatched at the right time, to the right place, in the right quantity.[1]

The red globules of the blood of all vertebrate animals contain a coloring matter similar to, if not identical with, that of man, but differ from the globules of human blood as to form, size, and structure. The detection of this difference is sometimes of importance in courts of law in the decision of questions relating to the stains upon murderous weapons, or upon garments, floors, etc.

165. **The White Corpuscles**, or *leucocytes*, are rounded, colorless cells, each containing a nucleus. They are composed of protoplasm, and have the power of amoeboid movement.[2] They move from place to place, and also "migrate," *i.e.* escape from the capillaries into the surrounding tissues. Powers says of this migration, or *diapedesis*, as it is technically called: "Under certain circumstances, both white and red corpuscles may escape from the vessels, and pass or wander into the adjoining lymphatics. The escape of the white corpuscles appears to occur normally, whilst the escape of the red occurs only when the pressure of the blood against the walls of the capillaries is much increased, or when there is retardation of the blood current, as in inflammation. In the case of the white corpuscles, the attraction between the corpuscle and the capillary wall seems to be increased, the corpuscle begins to bore its way through the wall, assumes an hour-glass form, part being within and part

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[1] The red corpuscles are believed to be formed in the red marrow of bones, the lymphatic glands, and the spleen. After fulfilling their allotted task they are for the most part destroyed in the liver.

[2] These corpuscles are not peculiar to blood, but are found in lymph, chyle, and other fluids.

without the lumen of the vessel, and it finally escapes altogether into the adjoining tissues." How far the nutritive processes are influenced by the migration of blood corpuscles is not definitely known.

There is reason to believe that certain of the white corpuscles have the power of eating up bacteria and other noxious matter with which they come in contact, as the amoeba takes its food. Such cells are called *phagocytes*, and their principal function seems to be to destroy disease-producing bacteria which may have entered the body by the lungs, alimentary canal, or torn skin. Their number is probably decreased by fasting, and increased by good living, as are the white corpuscles in general. Successful resistance to infectious diseases is believed to depend largely upon the power and activity of the phagocytes. If they are overpowered by the number and strength of the bacteria, the invaded tissues die, and may slough away.

166. Coagulation of Blood.—Blood *coagulates*, or clots, spontaneously when exposed to atmospheric air. This property is peculiar to blood. If it were not for this coagulation, we should be liable to bleed to death from even a slight cut. In most of the other warm-blooded animals, coagulation is more prompt and thorough than in man, and there may be extensive injury to blood-vessels without fatal results to the helpless animals. But man is able, by pressure for a time upon a bleeding vessel or by tying the two cut ends, to cause coagulation, and so lessen the danger from extensive hemorrhage.

Seldom does the blood clot in the living body, unless the circulation is impeded or arrested by some disease or by an injury to the inner coat of a blood-vessel. A clot

formed in a blood-vessel may interrupt the blood supply to a part of the body and cause the death of that part, or it may be sent in the blood current to the brain, and cause paralysis of a portion of the body, or death of the entire body. A "bruise-spot" is the discoloration produced by blood escaping from injured capillaries and coagulating in or under the skin. The rapidity with which it disappears depends upon the severity of the injury, the relative thickness of the skin, the vascularity of the part injured, and the health of the person. When blood is poor and thin, as in scurvy and other blood diseases, it flows readily from wounds or from the impoverished tissues, producing dangerous hemorrhages and many bruised spots. The drawing of a tooth or the scratch of a pin in such cases is liable to result in severe bleeding.

Coagulation is essentially the formation of *fibrin*, from the *fibrinogen*, a proteid constituent of the plasma, by the action of a fibrin ferment. The fibrin forms in interlacing threads, which entangle the corpuscles. Soon this network shrinks in all directions and squeezes out a pale yellowish fluid, the *serum*, which consists essentially of all the ingredients of the blood, except the corpuscles and fibrin. The semi-solid mass which remains is the coagulum, or clot, and retains most of the corpuscles.[1]

167. The Quantity and Quality of Blood. — The entire *quantity of blood* of an individual is about ten per cent of

[1] Fibrin may be seen in the fibrous filaments remaining after thoroughly washing a clot of blood, or in the fine threads which cling to a bundle of twigs with which fresh blood has been thoroughly beaten for a time. Such blood remains uncoagulable, and is said to be defibrinated. Fibrin is so tough that buttons and door handles have been made from the blood of animals.

the weight of the body. Of this quantity about one-fourth is distributed to the heart, lungs, large arteries, and veins, one-fourth to the liver, one-fourth to the muscles, and one-fourth to the remaining organs and tissues. The brain utilizes one-fifth of the entire quantity of blood.

The *quality of blood* varies much in different individuals. The old expressions, "rich blood," "poor blood," and "blood will tell" have much of truth in them in a physiological sense, for so-called "blood diseases" are often handed down from one generation to another. Blood may become so poor (thin and watery) from inattention to hygienic requirements that health is impossible. On the other hand, chilliness and pallor of countenance will disappear, strength and energy will return to the feeble, when poor blood has been enriched by good food, abundance of sleep, by warmth, cleanliness, and frequent exercise in the open air.

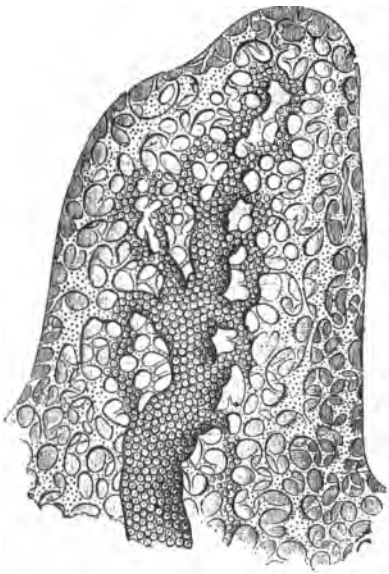

Fig. 72.

Lymphatic Vessels of a Papilla of the Palm of the Hand, greatly magnified.

168. The Lymph.—In addition to the blood, the *lymph* is widely distributed throughout the body. It is, in fact, blood plasma (without the red corpuscles), which constantly exudes from the capillaries to bathe the cells of the tissues, bringing nutri-

tive material directly to them. From the cells it receives waste products and conveys them into minute and delicate vessels, called *lymphatics*, which drain the intercellular spaces, and finally empty into the blood current.[1]

169. The Lymphatics are most abundant in organs well supplied with blood-vessels, such as the glandular organs, the mucous membrane, and the skin (particularly that of the soles of the feet and the palms of the hands), and are absent in the non-vascular tissues.[2]

Fig. 73.
Superficial Lymphatics of the Hand and Forearm.
G, lymphatic gland.

The lymphatic capillaries converge after leaving the various tissues, the tubes becoming larger as they approach the heart. Those from the right side of the head and neck and from the right upper extremity form the right lymphatic duct, which opens into the venous system at the junction of the right subclavian vein with the right internal jugular vein. The lymphatics of the lower extremities enter the abdominal cavity, and with the abdominal lymphatics (including the lacteals) form the beginning of the thoracic duct. At the base of the neck, before this duct empties

[1] These vessels are so small that they cannot be readily seen unless injected with quicksilver.

[2] Those instances related of blood poisoning, by mere contact of poisonous material with the tender parts of the skin or mucous membrane, are probably due to the absorption of the poison by the lymphatics.

into the left subclavian vein at its junction with the left internal jugular, it is joined by the lymphatics from the

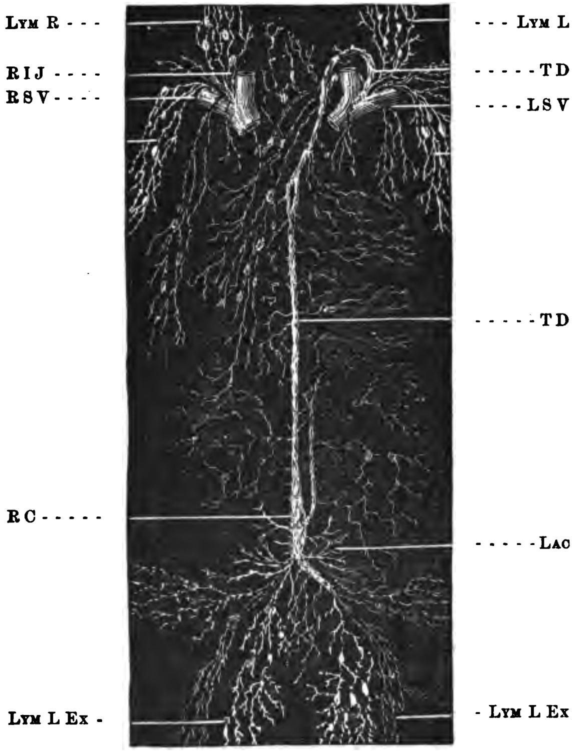

Fig. 74.

Thoracic Duct.

Lym R, lymphatics of right side of head and neck.
Lym L, lymphatics of left side of head and neck.
RIJ, right internal jugular vein.
RSV, right subclavian vein.
LSV, left subclavian vein.
TD, thoracic duct.
RC, receptacle of the chyle.
Lac, lacteals.
Lym L Ex, lymphatics of lower extremities.

left side of the head and neck and from the left upper extremity. Thus the lymph is mingled with the venous

blood before its arrival at the right side of the heart.[1] The flow of lymph is aided by valves in the lymphatics, similar to those in veins.

170. Lymphatic Glands. — In the course of the lymphatics everywhere in the body are numerous little knots, called *lymphatic glands*.[2] These are spongy networks, which filter injurious bodies, such as bacteria, from the slowly moving lymph, and destroy them, if their number is not too great. It is believed that these glands also supply leucocytes to the blood. When many of them are hardened or otherwise altered, as in scrofula, health fails and the person grows thin, though the food may be suitable in quality and abundant in quantity.[3]

171. Intimately connected with the circulation of blood and the conveyance of lymph are the operations of secretion, transudation, and absorption, which form a large part of the processes of nutrition. Though the various parts of the body are constantly changing, the general normal condition is maintained, through the movement and renovation of the blood and lymph.[4]

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[1] About the year 1600 the thoracic duct was discovered; in 1622 the lacteals, but until 1649 they were supposed to empty into the liver; in that year (1649) the receptacle for chyle was discovered, and the fact that chyle was carried into it, and thence into the venous system. It was not until 1650 that the other absorbent vessels, *i.e.* lymphatics, were discovered, first in the liver, and then in the other parts of the body.

[2] About 700 in number. These glands are not infrequently enlarged, —for instance, upon the head, or in the neck, from some irritation of the skin, from a sore throat, etc., —and can then be readily felt.

[3] The lymph current is a very slow side-stream to the blood current, and seems to provide for emergencies, absorbing the excess of plasma and the excess of wastes.

[4] The spleen, thymus gland (a gland found in children upon the front of the neck), and other ductless glands, in connection with the blood-

172. The Spleen is a dark, purplish organ, situated in the left side of the abdomen, near the stomach. It has a firm capsule, but its interior is a sponge-like tissue, containing in its meshes the *spleen pulp*. This pulp is composed of red and white blood corpuscles. The blood circulates abundantly through the spongy tissue, but not in firm tubes. The spleen becomes gradually distended with blood after a hearty meal or after severe exercise, and then shrinks. It also enlarges and hardens when the blood has an excess of white corpuscles, as in malarial and other diseases.[1] The function of the spleen seems to be to supply leucocytes to the blood, and to renovate or destroy some of the old and worn-out red corpuscles.

173. Effects of Alcohol and Narcotics upon the Organs of Circulation and the Blood.—Diluted alcohol, taken internally, is readily absorbed by the blood. In small amount, it slightly increases the action of the heart and the flow of blood, produces flushing of the face, glistening of the eyes, and a general stimulating effect. Repetitions of this excitation frequently lead to the taking of larger and larger amounts. These tend to tire the heart and blood-vessels, and to weaken their walls by the deposit of fat or of calcareous matter, especially in the arteries. A heart so weakened gradually becomes too feeble to pump the amount of blood necessary to sustain more than ordinary muscular exertion, and may give out when overtaxed. The diseased arteries from the same cause may rupture, and paralysis or death result.

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vessels, elaborate in a similar manner formative constituents of the blood. When these glands are diseased, the blood is likely to be more or less white and watery.

[1] So enlarged and hardened it is known as "ague cake."

174. *Tobacco*, used habitually, may produce through the nervous system functional derangement of the heart, known as "tobacco heart," attended by pain, faintness, and severe palpitations. This functional derangement, in a naturally weak organ, may lead to structural or organic disease of the heart.

175. While *opium* and other narcotics readily enter the blood and impair it, their action in the body is manifested principally in derangement of the general nervous system.

QUESTIONS.

1. State what is meant by the circulation, and what is its object.
2. What are the organs of circulation?
3. What is the chief organ, where situated, and what is its structure?
4. How does the blood pass from the auricles to the ventricles?
5. What keeps it from returning from the ventricles to the auricles?
6. What other valves are there in the circulation, and where?
7. By which side and parts of the heart is pure blood transmitted?
8. Describe the circulation of the blood.
9. Does the heart, like other muscles, have rest?
10. How are the movements of the heart effected? How affected?
11. What can you say as to its vitality?
12. Describe the arteries and their function.
13. What is the pulse and its rate?
14. What causes blushing and pallor? Apoplexy?
15. Describe the capillaries.
16. How are the nails, cartilage, etc., nourished?
17. Describe the veins.
18. Where, then, would you compress a bleeding artery to stop its flow? Where a vein?
19. What facts show the importance of blood?
20. Of what is blood composed?
21. How does it appear under the microscope?
22. What is the function of the red corpuscles?

23. What is the coagulation of the blood, its cause, and value?
24. When does blood clot in the blood-vessels?
25. What is paralysis? A bruise? A hemorrhage?
26. What proportion, in weight, of the body is blood?
27. Describe lymph, lymphatics, and the lymphatic glands.
28. Where do the lymphatics empty?
29. What processes of nutrition are intimately connected with the circulation of blood and lymph?
30. What are the effects of alcohol, tobacco, etc., upon the blood and organs of circulation?

CHAPTER XI.

FOOD.—DIETETICS.

176. The Uses of Food.—*Food*, in a physiological sense, is anything which, when introduced into the system, will nourish some part of the body, supply heat or other form of energy, or aid in the discharge of the various processes which take place in the body. Some indigestible and innutritious materials (such as bran and the skins of small fruits), when associated with food substances, are important aids, if taken in moderate amount, in stimulating the alimentary canal. Substances too much refined are not the best adapted to persons in health.

Food that produces heat or other forms of energy in the body may be considered as *fuel*, for it is literally burned, just as coal is burned in an engine to produce heat and work. This is accomplished by its combination with the oxygen of the atmosphere, which we inhale in breathing. Though we do not call oxygen a food, it is such in reality, as without its aid, food substances would be of no service in the body.

Food which is used in excess of the daily requirements of the body is stored in the system for future needs, principally in the form of fat. When a person is starving, the body uses this reserve fat, before it feeds upon its muscles and other albuminous tissues. As these tissues are consumed, the body becomes weaker and weaker, until death results. How long a person can live, absolutely de-

prived of food, depends upon how much reserve material he has, and also upon how warm he can be kept and the amount of exercise he takes.

177. Sources of Food. — Food is furnished to us by all the kingdoms of nature ; and as our knowledge extends, new food products are discovered. It is worthy of note that the ordinary food supply of different countries varies in kind and quantity, and that substances highly esteemed by some parts of our race are repulsive to us, while some of our most valued foods are considered by others as even poisonous (*a*). Unlike the lower animals, man can prepare, by sifting, grinding, cooking, etc., such food as he cannot or does not care to eat in its natural state. He is thus able to remove what may be hurtful, and to retain what is beneficial.

178. The Food Elements[1] needed by the body are *proteids*, *carbohydrates*, *fats*, *salts*, and *water*. No one of these food elements alone can support life. Experience has shown that they are all needed, the proportion of each varying, according to the requirements of the individual, for warmth, for repair of tissues, and for energy in mental, muscular, or other work.

179. Proteids contain nitrogen, carbon, hydrogen, and oxygen, and some of them also sulphur and phosphorus. Being the only food elements which contain nitrogen, they are specified as nitrogenous, and the foods of which they form the principal part are nitrogenous foods. From their resemblance to albumin — the most prominent of

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[1] Sometimes called nutritive ingredients, alimentary principles, food principles, or proximate principles.

the proteid elements—they are also called albuminoids, and the foods which contain them in large amount are known as albuminous or albuminoid foods.

180. Sources of Proteids.—The proteids of food are obtained from both the animal and the vegetable kingdoms, for albuminous compounds exist not only in nearly every animal fluid and tissue, but also in vegetables, especially the cereal grains. These grains, and such vegetables as beans and peas, which are rich in proteids, may sometimes be substituted for animal food. While the nitrogenous constituents of vegetable food are similar to those of animal food, their relative quantity is much smaller, and the indigestible residue of vegetable food is much larger in amount.

The principal proteids of animal food are albumin, myosin, fibrin, and casein; of vegetable food, albumin, gluten, and casein.

Albumin is found in flesh, blood, milk, in many vegetable juices and solids, and in its purest form in the white of eggs.

Myosin is the basis of lean meat, and *fibrin* is found in its fibrous portion.

Gluten exists in variable quantity in the cereal grains, being most abundant in wheat. It is a highly nutritious compound, composed of several albuminoids, together with oil and inorganic matter.[1] Gluten gives to dough its adhesive character.

Casein exists in milk, and in a coagulated form in cheese. It is also extracted from beans, peas, and similar

[1] Gluten is easy of digestion, and substances which contain it in considerable amount are readily digested, even by invalids and dyspeptics.

vegetables, and is then known as vegetable casein, or legumin.[1]

181. Value of Proteids. — Proteids are *the indispensable tissue-forming elements of food.* They build up the nitrogenous materials of the body, — *i.e.* muscles, tendons, etc., — and supply the albuminoids of blood, milk, and other fluids.

From the presence of albuminous substances in the animal economy, the necessity of a sufficient supply of albuminoids in food is evident, yet *they cannot of themselves alone support life.* Animals fed exclusively on them lose appetite, become emaciated, and die of starvation. Though they are of great importance, and exhaustion follows more rapidly when they are withheld than when the body is deprived of certain other food constituents, yet to distinguish them as "the nutritious" elements of food is misleading. This misunderstanding as to their value is to be regretted, for the value of other food constituents is thereby lost sight of. When proteids are used in larger amount than is needed to build and repair the tissues, some of them are burned to produce energy; others are probably converted into fat. In a way not thoroughly understood, more fat is stored in the body when proteids (especially meat) are eaten with fatty food, than when the latter alone is eaten.

182. Excessive Use of Proteids. — Albuminous substances can be eaten for a longer time without loathing than most other food constituents. The foods which contain them, especially meat, are for the most part palatable, and give us the "sensations of energy, of feeling up to the mark,

[1] "The article called *tao-foo*, made by the Chinese from peas, is apparently identical with cheese." — Flint, *Text-book of Physiology.*

of being equal to work, which are so pleasant to all." Hence they are apt to be consumed in too large quantities, and the stimulus afforded by such food is quite often obtained at the risk of biliousness and gout, for the waste products resulting from the digestion of so much nitrogenous food are not thoroughly eliminated from the body, and act as poisons in the blood. Especially is this the case if there is insufficient exercise, if the digestive secretions are not sufficiently abundant or active, or if the liver and kidneys are not in healthy working order.[1]

183. Nitrogenous, Non-albuminous Food Elements are associated with some food substances. They are known as gelatinoids, nitrogenous extractions, and amids. They cannot take the place of albuminoids, but afford some heat and energy. Examples of such substances are the gelatinous material of connective tissue, collogen of tendon, ossein of bone, kreatin, and allied compounds, which are the chief ingredients of beef teas and of most beef extracts. Combined with fats and carbohydrates these substances enable the body to do with less proteids. Gelatine, often given to invalids in the form of jelly, does not act as a body builder and restorer.[2]

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[1] Luxurious and well-to-do people frequently eat too much, especially of rich, albuminous food, and take too little exercise. A business reverse which compels them to live on simpler food and to take more exercise is, so far as their health is concerned, a blessing in disguise.

[2] In 1841 the physiologist Magendie, in connection with a French committee of investigation, showed that animals fed on pure albumin, fibrin, or gelatine lost their appetites and died, with all the evidences of starvation, about the twentieth day. On the other hand, raw bones, containing, as they do, fat, albumin, water, and salts, as well as gelatine, are capable of supporting life. The same committee found that dogs could live and be nourished for a considerable time on gluten alone.

184. Carbohydrates and Fats consist of carbon, hydrogen, and oxygen, but the amount of oxygen is greater in the carbohydrates than in the fats. Carbohydrates of vegetable origin are the starches, cane and grape sugar, dextrin, gums, and cellulose (woody fibre). Those of animal origin are lactose, or sugar of milk, and glycogen (animal starch). Carbohydrates constitute a large proportion of all cereal grains.

185. Value of Carbohydrates.—Carbohydrates and fats *are the chief fuel constituents of food.* Both are readily oxidized in the body, giving off water and carbon dioxide. Their oxidation produces proportionately more heat and muscular power than that of proteids. Both are transformed into the fat of the body, and are mainly responsible for the storage of fat. The Tyrolese chamois hunters, it is said, find that they can endure greater fatigue with beef fat as their food than with the same weight of lean meat. The strength of the Hindoo and of the Irishman, the one living mainly on rice and the other on potatoes, is well known. Still, the amount necessary of such foods to furnish that strength is very large in comparison with that required by a mixed animal and vegetable diet. Necessary as are the carbohydrates and fats, like the albuminoids and other alimentary principles, *none of them alone will support life.*

Either carbohydrates or fats, if used frequently or in large quantities to the exclusion of other food elements, are not easily digested, and may prove injurious. Vegetables which contain a considerable amount of carbohydrates need to be well cooked, especially if they are old or hard, in order to soften the tough cellulose and break up the starch granules. We can readily digest a large

part of the cellulose of young and tender plants, like lettuce, celery, asparagus, and carrots.[1]

186. Starch is the principal carbohydrate in vegetable food, and though ordinarily a fine white powder, under the microscope it is seen to consist of granules. These vary in size and form, according to the kind of starch.[2]

Starch is distributed through the vegetable kingdom in the form of thin cells, in tubers, seeds, stems, and fruit.

A *B* *C*

Fig. 75.

A, Cells of raw potato, starch granules in natural condition. *B*, Cells of partially cooked potato. *C*, Cells of a thoroughly cooked potato.

It is especially abundant in the cereals, and in potatoes, chestnuts, beans, rice, and peas. Arrowroot, tapioca, and sago, which are extractions from various plants, are nearly pure specimens of starch.

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[1] "The different nutrients can, to a greater or less extent, do one another's work. If the body has not enough of one for fuel, it can use another. But, while the protein can be burned in the place of fats and carbohydrates, neither of the latter can take the place of the albuminoids in building and repairing the tissues. At the same time the gelatinoids, fats, and carbohydrates, by being consumed themselves, protect the albuminoids from consumption."—PROF. W. O. ATWATER.

[2] "They cannot be distinctly seen with the naked eye, and are so extremely minute that wheat flour, ground to an impalpable dust, contains its starch granules mostly unbroken and perfect."

Cooked starch is more readily digested than raw, as cooking causes the granules to swell and burst. A homogeneous jelly-like mass results, composed mainly of dextrin, or transformed starch, which is readily changed into maltose by the digestive secretions. A crust of bread, with its starch changed into dextrin by thorough cooking, is more digestible than the inside of the loaf, where the starch is too frequently not sufficiently cooked. During the process of maturing, a part of the starchy contents of fruits and vegetables is changed into dextrin by the ferment action of a peculiar vegetable substance known as *diastase.* This is the principal reason why ripe fruit is more digestible than unripe.[1]

Though cooked starch is in general promptly transformed by the digestive process, if taken in excess, to the exclusion of other food material, fermentation results, the appetite is weakened, and digestion is impaired. Therefore, persons living chiefly on bread and tea, or on bread and potatoes, or, as sometimes happens in the case of young children, upon arrowroot and corn starch, often suffer from an acid stomach.[2]

187. Sugar is closely related to starch in chemical composition, but is distinguished by its sweet taste, its solubility in water, and the crystallization which occurs upon boiling a watery solution. Some varieties of sugar readily ferment—that is to say, decompose, and are converted into alcohol and carbon dioxide—on exposure to heat and

[1] Gums, mucilages, and other substances known as *amyloids*, and associated with starch in certain vegetables, have comparatively little food value.

[2] Starchy foods should be given sparingly to very young children, in whom the saliva and pancreatic juice are not very efficient.

moisture, or in the presence of an organized substance known as yeast.

There are several varieties of sugar. The most important of these are *cane sugar*, *glucose* or *grape sugar*, and *milk sugar*.[1] Of these varieties, cane sugar is the sweetest and most soluble.

Sugar has a high fuel value, and renders other food more palatable. It is absorbed into the system almost as quickly as water, acts promptly, and is especially serviceable when the diet is deficient in starch and fat (*a*). But if used immoderately it may make the consumer unduly fat, interfere with the appetite for more substantial food, and cause acidity of the stomach and decay of the teeth. Good candy—*i.e.* candy not impaired by deleterious coloring matter or other substances—can be safely used by most persons, if eaten in moderation.

188. Fats are obtained principally from the fatty tissue of animals and from cream. Many vegetable substances also contain fat, especially oats and Indian corn, cocoa, beans, nuts, and olives. The digestibility of fat varies with individuals, and with the kind eaten; some persons dispose easily of that of bacon or beef, while others readily digest fresh butter only. Animal fat is, as a rule, not so easily digested as vegetable oils. Some kinds of fat, not being pure, easily decompose on exposure to air; or, on being heated, produce acids, which prove very indigestible and irritating.

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[1] Cane sugar is obtained from sugar cane, beet root, sugar maple, etc. Glucose is combined with cane sugar and fruit sugar in peaches, pineapples, and strawberries; with fruit sugar in honey, grapes, cherries, and dried fruit; and is frequently found in the animal fluids. Milk sugar is the saccharine ingredient of milk.

189. Value of Fat. — Fat is essential to *cell growth* and to *general nutrition of the body*. A diet free from fat will not support life. Eaten in sufficient quantity, it is a preventive of that defective nutrition which finally ends in chronic nervous diseases and in scrofula and allied affections.[1] On the other hand, too much fat is not readily disposed of in the body, but produces skin eruptions, unduly increases the adipose tissue, especially about the heart and other organs, and thus impairs health.

The *fuel value* of fat is more than twice that of proteids or carbohydrates. We need proteids; but fat, coupled with enough of the carbohydrates, decreases the amount of proteids necessary to maintain the nitrogenous equilibrium of the body. This is a matter of importance, especially for the poor, or when proteids are not readily obtained or not easily digested. Fat is much used in hot countries in the shape of vegetable and fish oils, when meat is scarce or is prohibited by religious opinions (*a*). The diet of the inhabitants of these countries is mainly a cereal one, and usually affords sufficient albuminoids for the building and repair of tissues.

190. Not only does fat, coupled with carbohydrates, save the consumption of proteids, but "when we wish to get our food in a more condensed form, we can use fats freely in connection with proteids, and lessen the amount of carbohydrates. In army dietaries the amount of fat

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[1] "This is probably one of the reasons of the craving of children in our climate for butter, which presents oily matter to the digestion in an easily assimilable form, and is evidently a valuable dietetic agent."

It is probably true that most of the persons who are benefited in this country by cod-liver oil, in Switzerland by neat's-foot oil, and in Russia by train-oil, would not need these oils as medicine if their food had contained sufficient oil or fat.

is largely increased for marching and for great exertion, the quantity being three times more than that allotted to garrison life."

Experience seems to show that we should not consume less than two ounces of fat per day, but we may increase it to eight or nine ounces if we decrease one or both of the other two great constituents of food.

191. The heat-producing property of fat renders it especially valuable in cold weather and in cold climates, where it is eaten by the inhabitants in enormous quantities, foür to five pounds per day being the ordinary amount for the average adult (*a*). Sailors who may be averse to fatty food learn to drink freely of oil when wintering in the Arctic regions, and enjoy the fat portions of the seal, walrus, and other marine animals.[1]

192. Water. — The *inorganic constituents of food* are *water* and the *chemical salts*. Of all substances, a regular supply of water is the most essential to the maintenance of life. If deprived of it for eight or ten hours, far greater inconvenience, pain, and debility is suffered than upon a

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[1] "People belonging to the well-to-do classes, unless they have given special study to the subject, seldom realize the importance of fat in our economy. Fat means to them fat meat, suet, lard, and the like, and the much eating of these is considered proof of a gross appetite; they do not consider how much fat they take in eggs, in milk, in grains like oatmeal and maize, in the seasoning of their varied dishes, and in their well-fattened meats, where, as in an average piece from a very fat mutton, they eat twice as much fat as proteid, without knowing it. Indeed, a well-fed man of the upper classes may have more fat in his daily diet than has the freshly arrived Michlenburg laborer, who spreads a quarter-inch layer of lard on his bread. The latter cannot take his fat in unsuspected forms; he craves this principle with his plain vegetable diet, and must take it as he can get it." — MRS. ABEL, *Practical and Sanitary Cooking*, etc.

similar deprivation of solid food. With water, life may be sustained without the aid of other food for several weeks; but, if it is entirely withheld, death is likely to result in a few days (*a*).

Water is present in all the tissues and fluids, and constitutes about 70 per cent of the entire weight of the body.[1] It dissolves certain food substances, and gives fluidity to the blood, lymph, and secretions, enabling them to perform their functions of introducing into the body and discharging from it substances held by them in solution. The elasticity of bones, cartilages, and muscles, and the flexibility of tendons and other tissues, are largely due to its presence. After performing its part in the various nutritive processes carried on in the body, about 20 per cent is exhaled from the lungs, 30 per cent discharged by the skin, and 50 per cent by the kidneys and intestines.

193. About 2½ quarts of water are required per day by the average adult, in temperate climates and doing moderate work, to replace the water lost by excretion. During severe labor, especially in warm weather or in hot quarters, the amount required is very much more. Probably about one-half of the water usually needed is obtained in the food we consume. Every kind of food contains water; for example, fat beef has about 50 per cent; potatoes, 75 per cent; bread, 35 per cent; peas and oatmeal, 15 per cent.

194. Salts are, next to water, the most important inorganic elements of the body and of food. They consist of

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[1] The necessity of water in food may be inferred from the statement that we are "two-thirds water and one-third land."

sodium chloride or common salt, iron, and the chlorides, phosphates, and sulphates of potassium, magnesium, and calcium. Salines influence solubility, and have much to do with the chemical changes of food substances.

Common Salt is essential to the life of animals, and is found in their every tissue, with the exception of the enamel of the teeth. It is also a constituent of nearly all food, and exists in small quantities in almost every spring, soil, and plant. The quantity taken with food as furnished by nature is generally insufficient for the needs of the body, and hence its use as a condiment. It assists in regulating the processes of endosmosis and exosmosis, and excites the digestive secretions, thus stimulating the appetite. Its value is indicated by the natural craving of the system for it, and by the results of experiments upon the lower animals. Without it, digestion would be imperfect and health could not be long maintained. We are told that the ancient laws of Holland "ordained men to be kept on bread alone, unmixed with salt, as the severest punishment that could be inflicted upon them in their moist climate." Animals will go long distances in search of salt, and if deprived of it, their hides become rough, their spirits dull, and they finally lose health and strength. In countries where salt is scarce, it is sold at fabulous prices (*a*).

Lime occurs principally as calcium phosphate and calcium carbonate, the first being most abundant. Lime is an ingredient of every tissue and fluid of the body, but is especially necessary in the bones and teeth, where it affords strength and consistency. A deficiency of lime salts renders the bones soft, so that they easily bend; hence, during early life, when the tissues are developing, lime salts should be supplied in comparatively large quantities.

Of all articles of food, meat, milk, and vegetable grains contain lime in the largest amount.

Of *iron* about one-third of an ounce exists in the body in connection with the coloring matter of the blood, of which fluid it forms about one one-thousandth part. Iron is a constituent of milk and eggs, and is sometimes found in water. Its importance to health is easily recognized, when, as a medicine, it restores color to the skin and enriches the blood.

Phosphorus and *sulphur*, in the form of phosphates and sulphates, are introduced into the body with proteid food substances, and enter into the composition of muscles and other tissues.

195. The Vegetable Acids — malic, citric, tartaric, etc. — are found in fruits and vegetables, combined with lime, soda, and potassa, forming salts known as malates, citrates, etc. These salts are indispensable in food, for in the body they are converted into carbonates, and assist in furnishing alkalies to the blood and other fluids.

196. Fuel Value of Food. — By the expression "fuel value of food" is meant the amount of heat power and of muscular and other forms of energy that various foods produce when oxidized in the body. Undoubtedly, intellectual activity is somewhat dependent upon the utilization of food material by the brain and nerves, but exactly what food substances produce this form of energy is not definitely known. Fats and carbohydrates are the chief producers of energy, but proteids sometimes act as fuel. The first two, by reason of their lack of nitrogen, cannot build and repair nitrogenous tissues, but they build and repair fatty tissue.

197. The energy of food in the body is estimated by physiologists just as if the food were burned outside the body, *i.e.* in heat units or calories.[1] "Taking ordinary food materials as they come, the following general estimate has been made for the average amount of heat and energy in one pound of each of the classes of nutrients:—

	Calories
In one pound of protein[2]	1.860
In one pound of fats	4.220
In one pound of carbohydrates	1.860

In other words, when we compare the nutrients in respect to their fuel values (their capacities for yielding heat and mechanical power), a pound of protein of lean meat or albumin of eggs is just about equivalent to a pound of sugar or starch, and a little over two pounds of either would be required to equal a pound of the fat of meat or butter, or the body fat."

198. Relative Value of Food Substances.—The table[3] on page 188 gives the composition of a few food materials.

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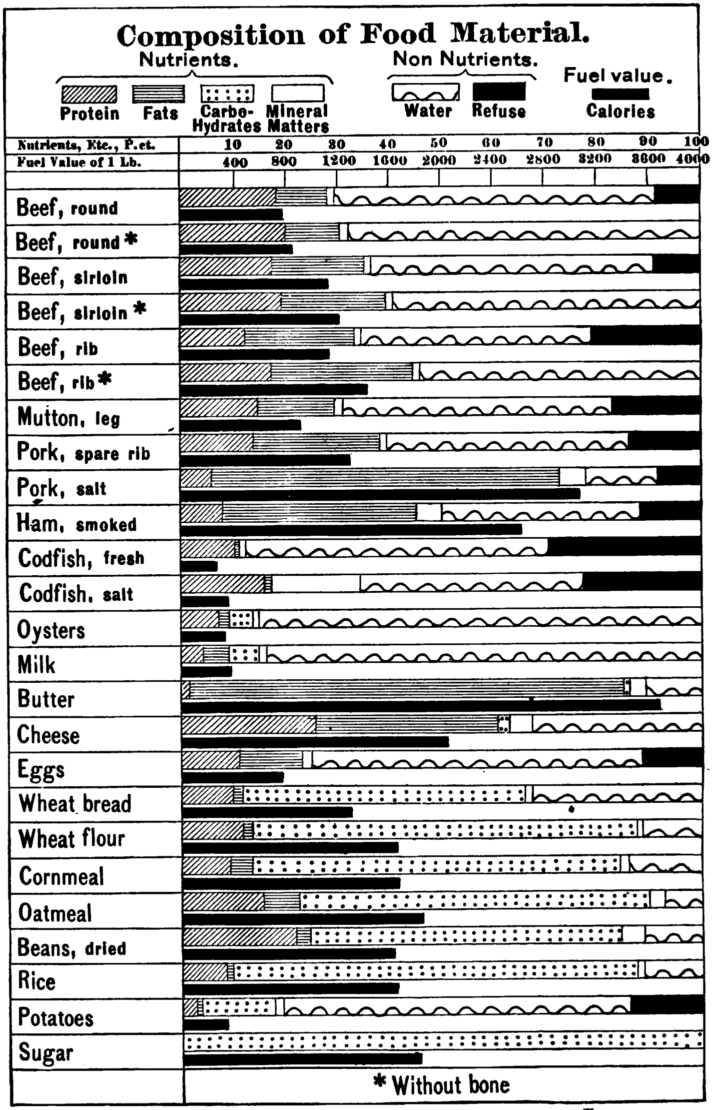
[1] The calorie is the amount of heat necessary to raise the temperature of one kilogram (2.2 pounds avoirdupois) of water 1° C., or one pound of water about 4° F. A foot ton is the energy (power) which would lift one ton, one foot. One calorie is equivalent in mechanical energy to 1.53 foot tons.

[2] The term protein, as used in this chapter, includes *all* the nitrogenous food constituents,—the nutritious proteids, and the materials which have little nutritive value, like kreatin of muscle tissue and amids of vegetable tissue.

[3] It represents the food materials in the form in which we buy them, including water and refuse, like bones and the skins of potatoes. It was prepared by Prof. W. O. Atwater, special agent of the United States in nutrition investigations, and published by the Department of Agriculture. Much of the material in this chapter is from recent publications by the government on food and diet.



Composition of Food Material.
Nutrients.
Non Nutrients.
Fuel value.
Protein
Fats
Carbo-Hydrates
Mineral Matters
Water
Refuse
Calories
Nutrients, Etc., P.ct.
10 20 30 40 50 60 70 80 90 100
Fuel Value of 1 Lb.
400 800 1200 1600 2000 2400 2800 3200 3600 4000
Beef, round
Beef, round *
Beef, sirloin
Beef, sirloin *
Beef, rib
Beef, rib *
Mutton, leg
Pork, spare rib
Pork, salt
Ham, smoked
Codfish, fresh
Codfish, salt
Oysters
Milk
Butter
Cheese
Eggs
Wheat bread
Wheat flour
Cornmeal
Oatmeal
Beans, dried
Rice
Potatoes
Sugar
* Without bone

Fig. 76.

Animal foods in general,[1] especially beef, have the most proteids; among the vegetable foods, wheat, oatmeal, peas, and beans head the list. These, therefore, are the foods best adapted to build and repair the tissues. The foods which have the most fats, such as butter and its substitutes and fat meats, have the highest fuel value. Grains, meal, and good flour have also a high fuel value on account of their carbohydrates. Fresh vegetables, such as turnips and cabbages, contain much water, and are mainly useful for their salts. The principal value of fresh fruits is in their salts and acids.

Milk comes nearest to being a perfect, or normal, food, because it contains all the food elements in about the right proportion; but by adults it must be taken in considerable quantity to afford of itself sufficient nutriment and fuel.

199. The Importance of a Mixed Diet. — After the first year or two of life, a mixed diet is best for all. One could live on bread or meat alone, but the exclusive use of either of these foods would entail great labor on certain digestive organs, and would make the disposition of a large amount of refuse of one kind very uncertain. And also, after a time, the food would become distasteful. The system of an adult doing moderate work requires daily about 20 grams[2] of nitrogen and 280 grams of carbon. Wheat bread contains 1 per cent of nitrogen and 30

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[1] *Fish*, as a rule, have so much refuse and water that they must be eaten in larger amount than other meat to afford the same amount of nutrients. *Eggs* contain more fat and proteids than milk, and about the same amount of mineral matter, but no carbohydrates. "A quart of milk, three-quarters of a pound of moderately fat beef, and five ounces of wheat flour contain about the same amount of nutritive material."

[2] A gram = 15.43 troy grains.

per cent of carbon, while meat has 3 per cent of nitrogen and 11 per cent of carbon. In order, therefore, to obtain the required amount of nitrogen, if bread alone is eaten, it will be necessary to eat about four pounds a day; in doing this, twice the necessary amount of carbon will be consumed. On the other hand, to obtain sufficient carbon from an exclusive meat diet, a man must eat about six pounds of meat a day, and then he would be taking six times the necessary amount of nitrogen.

Combinations of foods, such as meat and bread, bread and milk, meat and potatoes, pork and beans, crackers and cheese, are scientifically correct, and the results of experience show that they may be used as the essentials of each day's food. In addition to the flesh foods, heat foods, and work foods, we need water, air, mineral matters, and the flavors resulting from the cooking of food, or those which are added to foods to make them taste good.[1]

200. The Quantity of Food needed varies greatly, depending upon age, health, occupation, digestive powers, and other peculiarities, as well as upon the climate and season, the amount of clothing worn, the kind of food used, and

[1] "Surely the economical housekeeper who would throw out of the list of necessaries all the things that tickle the palate, that rouse the sense of smell, that please the eye and stimulate overtired nerves, just because these things contain but little food, would make a grave mistake. She may know just what cuts of meat to buy, what vegetables are most healthful and economical, but, if she does not understand how to make 'the mouth water,' her labor is largely lost. Especially if she has but little money should she pay great attention to this subject, for it is the only way to induce the body to take up plain food with relish. The list of these spices, flavors, harmless drinks, and the like is a long one. Unfortunately, we have no comprehensive word that will include everything of the sort, from a sprig of parsley to a cup of coffee. The Germans call them *genuss Mittel*, pleasure-giving things." — MRS. MARY HINMAN ABEL.

other circumstances. In infancy, a period of rapid growth and development, a proportionately larger amount of food is needed than at any other period of life.[1]

A healthy, growing boy, with the muscular strength and nervous energy of youth, will often eat, and perhaps requires, as much food as the average man; while old, feeble, and inactive persons require but very little food.

Active mental or physical work renders an abundance of substantial food necessary. Proper work cannot be accomplished on an insufficient or improper diet. It happens sometimes that in prisons, and even in charitable institutions, the daily ration is diminished below the physiological standard, for the sake of economy. If there is but little activity of mind or body, some diminution may not be attended with actual disease; but if active, healthy children are scantily fed, or convicts in prison are compelled to do hard work on a light-labor diet, sickness, great feebleness, and even death result.

Size alone does not determine the amount of food required. In fact, large and fat people often thrive on a scant diet, especially if there be a great indisposition to muscular exertion, while thin and diminutive persons, particularly hard workers, may eat and digest a very large amount. As people become better supplied with this world's goods, the tendency is to eat too much. Persons in moderate circumstances often thrive on what is con-

[1] During the first year of life a child should grow from six to eight inches, and should weigh at the end of the year two or three times as much as at birth. In the second year, the growth should be only about half as much as in the first. In the third year, only about a third as much. After the third year the weight and growth are more uniform. To meet these demands it is generally necessary to feed babies every two, three, or four hours.

sidered by many an insufficient amount of food. The body exposed to a cool, bracing atmosphere, or to extreme cold, demands an increased supply of food.[1] According to Dr. Hayes, the Arctic explorer, the daily ration of the Esquimaux is from twelve to fifteen pounds of meat, about one-third of which is fat.

201. Dietaries.—The knowledge of the kind and daily amount of food required by the average individual, in an aggregation of persons whose social and hygienic surroundings are about the same,—as in an army, on shipboard, or in an institution,—affords a basis upon which to calculate the kind and amount needed by a number of persons. From such estimates Dietaries or Diet Tables are constructed.

The dietary standards[2] most commonly adopted in Europe are those prepared by Professor Voit of Munich, based largely upon observations and experiments among people in Bavaria. Voit's standard for a man performing moderately hard work, as a mason or a carpenter working

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[1] The ravenous appetite noticed amongst the inhabitants of cold climates may be due, in part, to the fact that their food supply is very irregular, so that when food is obtained they eat to excess.

[2] "The term 'dietary' is used as representing the *daily food actually used*, while the term 'dietary standard' is applied to the *quantities of nutrients* assumed to be appropriate for the daily food in the given case. The standard being once decided, dietary tables may be calculated by combining various food materials, which, according to their chemical composition, will furnish the quantities of nutrients which the standard calls for. Standards have been obtained by dietary studies of the actual food consumption of individuals, or groups of persons of different age, sex, occupation, and condition of life, and by so-called metabolism experiments with individuals, in which the income and outgo of the body are measured, and the effects of different kinds and amounts of food materials are learned."

actively ten hours a day, calls for 0.25 pound (118 grams) of protein,[1] and fats and carbohydrates in quantities sufficient with the protein to yield 3050 calories of energy. Professor Atwater suggests an American standard, somewhat higher than the European, allowing 0.28 pound (125 grams) of protein and 3500 calories of energy.[2]

202. "The American standard for a man of moderate work may be obtained approximately from

12 oz. of Round Steak, containing	0.14 lb. protein, and	680 cal. of energy
4 oz. of Butter, containing	0.00 lb. protein, and	900 cal. of energy
16 oz. of Potatoes, containing	0.02 lb. protein, and	310 cal. of energy
21 oz. of Wheat Bread, containing	0.12 lb. protein, and	1590 cal. of energy
53 oz., *i.e.* 3⅝ lbs., of nutrients.	0.28	3480

To this 53 oz., to afford a complete daily diet, is to be added from 50 to 80 oz. of water, and about 2 oz. of salt, etc." (*a*).

Hard muscular or mental labor requires more nutrients than are here shown; less work and sedentary occupations require a smaller amount. Women and children in general need less than men (*b*). The amount required for mere physical existence is very small.[3]

[1] As protein includes all nitrogenous food elements, the amounts of proteids required are not as large as the above figures would indicate.

[2] "The reason for the more liberal allowance is that investigations carried on in many parts of the United States indicate that the 'standard of living' is higher in this country than it is in Europe. People here are housed, clothed, and fed better than they are there. They have more of the comforts and opportunities of life, and make more of themselves. They work harder, accomplish more, and earn more wherewith to pay for better living. One essential, then, of this higher standard of living is better nutrition."

[3] "The first and most important principle established by Chossat is that absolute deprivation of food, and deficiency of food, are physiologically identical in their action on animal life. One acts quicker than

203. Experience, especially in armies, shows that the amount of lean meat required daily throughout the year is about the same. The fats and fat-forming elements should be apportioned to the amount of heat and work demanded. The body is not wholly dependent upon the food eaten any particular day, but rather on the nutrients as a whole taken during longer periods, for the system is probably storing nutritive material almost constantly.

204. **The Digestibility of Food** must, to a large extent, regulate the quantity to be eaten by each individual, especially of such kinds as beans, cheese, and rice. "We do not live upon what we eat, but what we digest and make use of." A healthy appetite is a good indication as to quantity and quality. Appetite normally asserts itself at regular intervals, or what we call meal-times, and may then be appeased by a moderate quantity of food. But an undue excitation of the muscles and mucous membrane of the stomach by irregular eating will produce in time the habit of an irregular secretion of the gastric juice, a consequent variable appetite, or a frequent and gluttonous desire for unnecessary food. The excessive amount

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the other, but the difference is merely one of duration and degree. Both are equally fatal in the end; and the end in both is regulated by the same law. Death arrives when the body has lost six-tenths of its weight, whether that happens after days, or months, or years."—CHAMBERS'S *Manual of Diet.*

In an overcrowded military prison, a diet of one-third of a pound of bacon and one and three-fourths pounds of unbolted meal daily caused much sickness and very many deaths.

During the siege of Paris, when the inhabitants were inactive, a diet which barely supported life consisted of ten ounces of bread and one ounce of meat daily.

of food thus eaten disorders the processes of secretion, assimilation, and excretion, and induces disease.[1]

The appetite may be aroused by attention to hygienic measures, such as proper mental and physical exercise, bathing, rest, and the proper selection, cooking, and presentation of food; also, by vegetable bitters and by condiments. It is diminished, on the other hand, by inattention to hygiene, by worry, by opium and other drugs, and by an abuse of alcoholic stimulants.

205. Variety of Food.—The system craves a *varied diet*, and the living for a length of time on even an abundance of food, if it be unvaried from day to day, will generally result in loss of appetite and in disease. The condition known as scurvy, exhibited by thin blood settled in spots under the skin, spongy and bleeding gums, and general debility, was formerly not uncommon on long sea voyages, especially in the Arctic regions, where the diet consisted largely of bread, tea, and salt meat. At the present time most vessels going on such voyages are supplied with lemons, lime juice, canned meats, fruits, and vegetables[2] (*a*).

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[1] "A voracious appetite is a condition which I suppose may be due to a very irritable state of the nerves of the stomach. . . . The voracious appetite, as we see it existing in children and young people, usually comes from undue encouragement. The greater the desire for food the more food the individual eats, and so he goes on, until he succeeds in consuming several times as much food as his system requires. Thus is thrown upon important organs the task of eliminating a quantity of useless material which ought not to have been taken. . . . A child perhaps is rather thin, and therefore encouraged to stuff, and by degrees the habit of taking enormous quantities of food is acquired, with the not uncommon result to the patient of getting thinner, instead of gaining in weight."—DR. LIONEL S. BEALE, *Slight Ailments*.

[2] It is required by law that lime juice be carried on board English ships, and served out to the sailors; hence, English ships are sometimes called "lime-juicers" by American sailors.

A similar condition is also seen on land in persons who are restricted to a diet in which fresh vegetables and fruit are lacking, or whose food consists mainly of potatoes or bread and tea, with little or no butter, meat, or milk. Soldiers in active service, with restricted and unvarying rations, often have an intense craving for fresh vegetables, such as onions and raw potatoes, which are excellent anti-scorbutics.

When a variety of articles cannot be obtained, varied methods of preparing and cooking the limited supply should be resorted to. "Good cookery means economy; bad cookery means waste."

On the other hand, however, there may be such a thing as *too great a variety*, and this also will destroy the appetite. People living in large hotels, and travellers eating frequently in bountifully supplied cars and restaurants, often suffer from dyspepsia and disturbed action of the liver and other digestive organs, especially if little exercise is taken. Epicures are apt to resort to alcoholic stimulants and to condiments, to excite their jaded appetites. In like manner, the under-fed and those living on a very small variety of food often fancy they need the assistance of alcohol in some form. In the former case the practice of abstemiousness, and in the latter a more bountiful and varied diet, is really what is needed.[1]

206. Adulteration, Freshness, and Maturity of Food. — Articles of food are often robbed of their value, and are sometimes positively harmful or even poisonous, in consequence of *adulteration*,[2] or of being immature, or stale,

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[1] Coffee-houses, holly-tree inns, and diet dispensaries, by furnishing suitable food, can do much to avert a taste for liquor.

[2] Adulteration is very common, and laws to control it are evaded. Frauds in food consist, first, in the addition of deleterious substances,

or over-ripe. Milk diluted with water, or skimmed of a large part of its cream, or that taken from unhealthy cows, is a common evil. "Measly meat," that is, meat containing animalcula, such as trichinae, is occasionally the cause of sickness and death.

Vegetables and meat of coarse texture, which are purchased for economical reasons, are usually tough and indigestible. Garden produce, especially corn, cucumbers, celery, and lettuce, when fresh, are desirable additions to the table, but may become indigestible and a source of disease, if allowed to become dry and stale. Immature fruits and vegetables lack the fully formed juices and salts, which are indispensable to make them serviceable as food. In over-ripe fruit and vegetables the juices and salts have decomposed, giving rise to new combinations which are hurtful.

207. Cost and Waste of Food.—"Half of the struggle of life is a struggle for food." With many people, one of the great problems is to obtain varied and sufficient food, leaving enough of the week's wages to pay for rent, fuel, light, clothing, and other necessaries. Investigations by the government show that in many families, from 50 to 65 per cent, or more, of the income is spent for food alone, and that the waste of food is enormous. It is estimated that frequently one-half of the food bought would be sufficient, if properly used.[1]

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such as salt of copper to pickles, and red lead to cayenne pepper; second, in the sale of fraudulent materials, such as cotton-seed oil for olive oil, of flour and a little mustard with turmeric for pure mustard, or of oleomargarine for butter; third, in the sale of substances not so fresh or in so good a condition as they are represented to be by the seller.

[1] In factory boarding houses where economical and healthful food was bought, properly cooked, and but little waste allowed, the cost of

The cost of food varies greatly in different parts of the same city. A knowledge of where to buy to the best advantage, of what to buy, and how to prepare and cook materials bought, will furnish a variety of good, substantial food at much less cost than is generally thought possible (*a*). Good home-made bread is cheaper than baker's bread. The tenderest meat, the finest fish, the highest-priced butter, and the most delicate vegetables have no greater food value than many of the less costly foods. Among such foods are milk, flour, cornmeal, oatmeal, beans, potatoes, substitutes for butter, the commoner kinds of fish, and cheaper meats.

208. Investigations show that even where considerable care is observed, one-tenth of the food bought is thrown away with the table and kitchen refuse. In most families, a much larger proportion is wasted. If the waste food of our cities could be utilized, it would nourish every hungry person in these cities.

Besides the household waste of food, there is another form, especially in this country, viz., the "trimming out" of the bones and fat of meat by the butcher. The bones could be used in valuable soups, and the fat for cooking purposes or for eating.

209. Proper Preparation and Cooking may render food of medium quality very serviceable. For example, the coarser and tougher parts of meat, and also vegetables of coarse fibre, can be rendered quite tender by prolonged boiling. On the other hand, the best food may be

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meals per week for women was from $1.60 to $1.75; for men $2.00 to $2.25. The eaters, though hard workers, were satisfied. Some of the foreign-born residents in our large cities manage to live and work at a cost of 11 to 18 cents per day for food for each person.

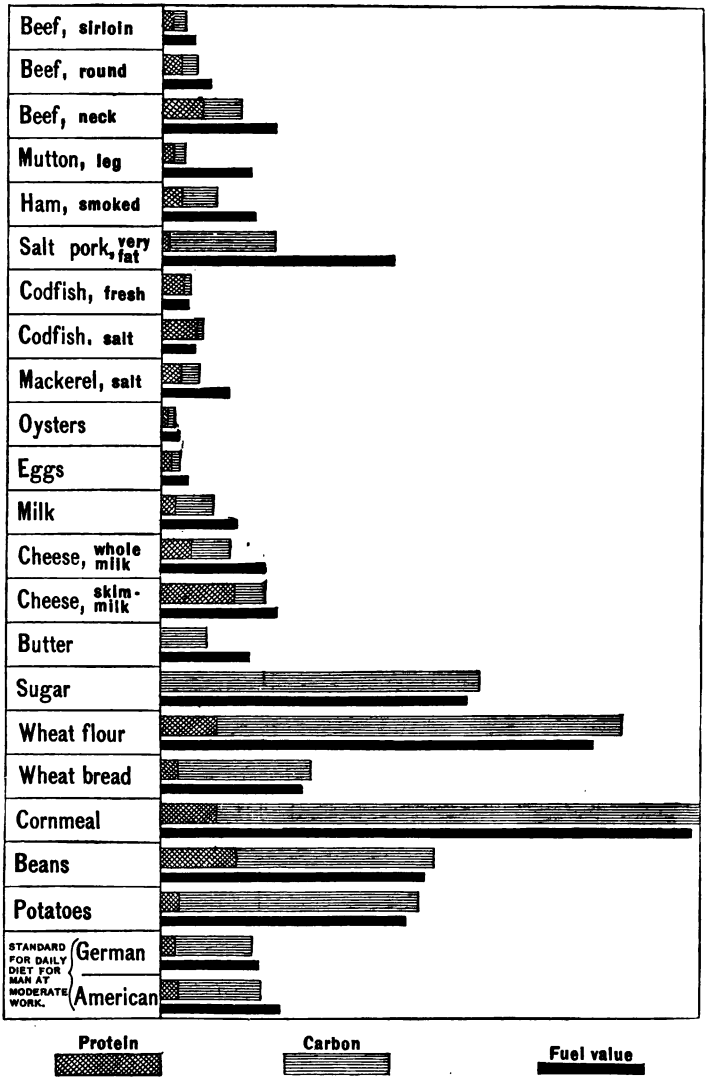

Fig. 77. (MAYO.)

Table showing the Relative Nutritive Value of 25 Cents' Worth of Various Foods.

made useless, unwholesome, and even dangerous, by improper preparatory treatment (*a*).

An important rule in roasting, boiling, or broiling meat is to produce at the start a rapid coagulation of albumin on the outer surface of the meat, so as to form a crust that may prevent the juices from escaping. This is done by subjecting the meat at first to a great heat, after which the cooking should proceed more slowly.[1] In like manner, the boiling of potatoes with at least the larger part of their skins on prevents the escape of much that is nutritious.

Frying, if not rightly conducted, is the most objectionable of all methods of cooking. Slowly heated fat evolves fatty acids which are more or less injurious, and, by penetrating the frying food, envelops its particles in grease. As fats are not digestible in the stomach, it follows that food so fried cannot be properly dissolved by the gastric juice, but becomes an irritant. To fry properly, the fat should be boiling hot before the food is put into it, that an outer crust may be formed, which will prevent the fats from penetrating to the interior. After this crust is formed, the temperature of the fat may be somewhat lowered.

210. Preservation of Food.—The processes of souring and putrefaction, by which food substances decompose,

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[1] On the other hand, the process of soup-making is facilitated if the meat is cut into small pieces and put into cold water, and the temperature slowly raised.

"The true science of cooking consists in the regulated and controlled application of heat, by which flavors are developed and the work of converting raw and indigestible material into nutritious food is accomplished. . . . High heat, common in iron stoves and ranges, renders much of the fat of food indigestible. The flavor of wheat bread, of white kinds of fish, etc., is best developed by a low and prolonged heat."—ATKINSON.

require the presence of moisture, a moderately elevated temperature, and access of atmospheric air or of some fluid containing oxygen. Decomposition is accomplished by the growth and multiplication of bacteria. The methods by which the decomposition of albuminoid matter and the activity of bacteria can be prevented, and the

Fig. 78.

"Open grates in cellars are often untrapped, and, when trapped, the traps are usually ineffective from want of water, or from being broken; and even if sealed by water, they are still an inefficient barrier to sewer gases, which can pass by absorption through water." — TEALE, *Dangers to Health*.

preservation of food effected, are canning, desiccation, freezing, or heating to about the temperature of boiling water[1] (*a*).

Food preserved in cans made of so-called tin, but which is in fact a compound of tin and lead, or in cans badly

[1] The smoking of meat and pickling in brine do not always kill the bacteria. Salicylic and boracic acids, though good preservatives of meat, are not desirable, as they sometimes produce digestive ailments. Dry cold and the injection of a solution of common salt are probably the best means of preserving meat.

soldered with lead, may become poisonous, especially if such food contain an acid, as is the case with tomatoes.[1]

Food cooked or left standing in brass or copper vessels that are not clean is dangerous to life. Ice boxes, storerooms, or cellars, which are not clean and dry or are imperfectly connected with drains, are constant sources of poison to milk, water, fats, and other foods which readily absorb poisons from the atmosphere.

211. Alcohol as Food.—Alcohol does not build or repair tissues, but evidence goes to show that, in a small amount, it may act as a partial food, like starch, sugar, and fat, by affording energy. It requires no digestion, and is readily absorbed, but it cannot be stored in the body for future use, as are starch, sugar, and fat. If taken in more than moderate amount, it impairs the working power of the brain and other parts of the body. Practically, therefore, it cannot be relied upon for food purposes, except by persons too ill to digest other substances, or by those at the point of starvation.

Leading physiologists of Europe, in a recent statement, say: "Thus far the results of careful experiments show that alcohol so taken, *i.e.* in a diluted form, in small doses, is oxidized within the body, and so supplies energy, like common articles of food." Professor W. O. Atwater, after a series of very careful experiments, corroborates the above statement.[2] Pure alcohol, and its equivalent in whiskey

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[1] Much of the harm arising from eating canned fruits, vegetables, and meat would be obviated if these goods were preserved in glass jars. Canned fish should be warmed through before being eaten, by placing the opened can in a basin of hot water. Failure to do this may cause sickness.

[2] These experiments were made by Professor Atwater and assistants at Wesleyan University, and the Storrs Experiment Station, for the

and brandy, were administered in water or coffee to healthy men, both at rest and doing active work, in divided amounts, six times a day, — three times with an ordinary diet of meat, bread, butter, and the like, and three times between meals. These experiments demonstrated: "1st. That the alcohol was oxidized, *i.e.* burned, as completely as bread and other ordinary foods, in the body and in the same way. 2d. In the oxidation the body transformed and utilized the energy of the alcohol, just as it did that of sugar, starch, and fat. 3d. The body, whether at work or rest, held its own just as well with the alcohol a part of the diet, as it did with a diet without alcohol." [1]

United States Department of Agriculture, "at the instigation of the Committee of Fifty for the investigation of the Drink Problem for the purpose of securing more accurate and scientific knowledge of the physiological action of alcohol." This committee is composed of presidents and professors of colleges, and other scientific men.

[1] "These experiments mark only a single step toward the settlement of the broad questions involved in the use of alcoholic beverages. They did not treat of the influence of alcohol upon the circulatory and nervous functions." — From a Government publication.

"It has been shown that when alcohol is taken in small quantities by certain persons, it is oxidized in the body and gives rise to heat and energy just as starch would, and is, therefore, a partial food. It must be noticed that it has been distinctly denied that it is a complete food, and stated that it cannot replace body tissue. But the experiments have been immediately seized upon by newspaper sensationalism and interpreted to mean that the use of alcohol in these small quantities is perfectly safe, and is, perhaps, to be recommended. The fact that it may thus be a partial food is taken to mean that it is a complete food, and in general the inference is drawn that physiologically alcohol is not injurious. Now nothing could be a more woeful misconception of scientific experiment. . . . The early experiments, upon which one class of statements is based, were made with the use of alcohol in large doses, while the later experiments, which form the basis of the other class of statements, have been made with small doses. In large doses there is no doubt that the

212. Professor Atwater says:[1] "In some experiments here[2] men have taken alcohol to the extent of two and a half ounces or thereabouts per day, the amount being divided into several doses, and practically the whole amount has been oxidized. In being oxidized, the alcohol has evidently performed one of the functions of food, — viz. that of serving as fuel for the body. But I certainly have never said that alcohol in that or any other daily quantity may not be injurious or dangerous. I have no doubt there are countless cases in which people take small quantities of alcohol, and do so habitually, without harm to health. But there are so many instances in which moderate use leads to excessive use, and men are ruined physically, mentally, and morally by that excess, that I could not say, and I do not see how any thoughtful man could say, that no harm comes from moderate drinking. Indeed, the exact opposite seems to me one of the most serious facts with which the physiologists, economists, sociologists, and moralists of our day have to deal."

213. To take alcohol regularly as a food is expensive, and attended ultimately with well-marked disadvantages and injurious effects, especially upon the nervous system, the digestive organs, and the blood. To obtain two and one-half ounces of alcohol a man would have to drink about two quarts of ordinary cider or lager beer, or nearly

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effects of alcohol are abnormal. Based upon experiments with small quantities, the statement is made that it is a food, and herein is the reason for the contradiction of statement" [as to whether alcohol is or is not a food]. — PROFESSOR CONN.

[1] In a letter to the author.

[2] See detailed report, Bulletin No. 69, published by the United States Department of Agriculture.

a bottle of claret or Rhine wine, or three average glasses of whiskey, two ounces each.

Professor Bartley[1] thus estimates the expensiveness of alcohol as food: "A quart of beer costs, by the glass, 20 cts.; by the pint, 14 cts. An equivalent amount of proteid matter in the form of milk (4 oz.) costs 1 ct., and in the form of meat about 1½ cts., while an equivalent amount of carbohydrates in the form of bread (4 oz.) costs about 1¼ cts. Assuming that the alcohol of the beer is all burned, and that it does no harm to any of the normal processes, we find that in calculated heat-value, one litre (one quart) of beer is equivalent to 5½ oz. of bread costing 1⅝ cts., or to 23 oz. of milk costing 6 cts., or to 13 oz. of meat costing 13 cts."

QUESTIONS.

1. Define food.
2. How do certain food substances act as fuel?
3. In what form is food stored in the body, and why?
4. Of what value are the coarser and sometimes indigestible portions of food?
5. Name the necessary food elements.
6. What are the chemical components of proteids?
7. What is the value of the proteids of food?
8. What are the carbohydrates? What is their food value?
9. Name some of the nitrogenous non-albuminous food substances.
10. From what sources are the proteids derived? from what the carbohydrates?
11. Of what value as food are water and mineral salts?
12. Where is starch found?

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[1] *Proceedings of the American Pharmaceutical Association*, 1898, Prof. E. H. Bartley, Professor of Chemistry, Long Island College Hospital.

13. When is starch most digestible?
14. Why is ripe fruit more digestible than unripe fruit?
15. Of what value is sugar in food?
16. Of what value is fat in food?
17. Name some of the fats that can be used as food.
18. What is meant by the "fuel value" of food?
19. How is it estimated?
20. What vegetable foods resemble the animal foods as tissue builders?
21. To what extent is water found in the body?
22. Why is a mixed diet important?
23. Upon what does the necessary quantity of food depend?
24. What are dietaries? What is their value?
25. What is meant by a "healthy appetite"?
26. Why should the diet be varied?
27. What may be the consequences of a too varied diet?
28. What is said of the resort to stimulants by the over-fed? By the under-fed?
29. Is it possible to select and use food that is both economical and nutritious? How?
30. What is meant by the proper preparation and cooking of food?
31. In what sense can alcohol be considered as food?
32. Why is it not a safe article to use as food?

CHAPTER XII.

FOODS.

214. Animal Foods.— The various articles of food may be classified as animal, vegetable, and mineral. *Animal foods* comprise the flesh of animals, their blood, secretions (milk, eggs, etc.), and also their various organs, which, though not containing so much nitrogen as flesh, are often more serviceable if eaten with proper vegetable food.[1]

Flesh, or *meat*, consists of muscular, connective, and adipose tissues, and contains albuminoids, water, fat, and salts. On account of its abundant supply of nitrogenous ingredients, its stimulating properties and pleasant taste, meat is usually ranked as a very nutritious food; and is therefore frequently eaten to excess, especially by little children, old people, the feeble, and the

[1] The organs most commonly used as food are the heart, the liver, the pancreas, or sweet-bread, the thymus gland, and the stomach, or tripe. Pigs' feet and ox-tails are highly esteemed by many. The heart — though composed almost entirely of muscle — is not always easily digested, while tripe is in general readily digested. The majority of the internal organs do not contain a large amount of nitrogen, and should be eaten, therefore, with grain food or vegetables comparatively rich in nitrogen. Bones, which are thrown away by many housekeepers because they are thought to be of no use, if well broken up, and submitted to prolonged boiling, will yield fat and gelatine which may form the basis, or "stock," for nutritious soups (*a*). When meat is roasted, the drippings contain much nutriment, and if boiled or submitted to prolonged simmering, as in the making of soup, much of the juice of the meat goes into the broth, leaving the meat quite hard. Such drippings and broth should be eaten with vegetables or cereals.

inactive (*a*). It requires to be properly prepared and thoroughly chewed before it can be safely swallowed or readily digested (*b*).

215. The various kinds of meat differ as to their *digestibility* and *nutritive value.* Beef, mutton, lamb, poultry, the flesh of many fishes, venison and other game are generally more easily digested than pork, veal, and salted or pickled meats.[1] Different parts of the same animal vary as to flavor and tenderness; but the cheaper portions may be rendered nutritious and palatable by proper cooking and seasoning.[2]

The age of animals, the kind of feeding, and the care observed in their housing and transportation influence the flavor and nutritiousness of the meat obtained from them. As a rule, the flesh of young animals is more tender than that of old ones; but meat, especially veal, from very young animals is unwholesome. Salted food, whether meat or fish, in small quantity, will stimulate the appetite, and is useful as an occasional article of diet.

Of all varieties of meat, beef is most often used, and is least likely to pall upon the appetite (*a*).

Pork, owing to the quality and quantity of its fat and the compactness of its lean meat, is not readily digested by many persons; but if obtained from animals properly fed and cared for, it is serviceable.

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[1] Hippophagy, or the eating of horse flesh, is advocated by good authorities, especially when beef is hard to obtain. "Such food is a valuable resource in France, where many of the people scarcely ever touch meat, in consequence of the enormous disproportion between the production of cattle and the population of the country."

[2] The lactic acid, which develops in raw meat a few days old, tends to soften the tough fibrous tissue and make the meat more tender. Dilute vinegar is sometimes applied to meat for this purpose.

As to *poultry* and *game*, tenderness and flavor are the most desirable characteristics. Old birds and old game-animals are generally tough and indigestible, and their flesh is often rank.[1] If there is any odor of decomposition, a bluish color, or spotting of the skin, poultry and game should not be used.

216. Fish should be eaten oftener than it is, as it furnishes an economical source of proteids and affords variety to the diet.[2] But the constituents of the meat of different kinds of fish vary considerably. Salmon, eels, mackerel, and halibut contain much fat and nitrogenous material. The following fish, in the order named, contain the largest amount of protein: cod, salmon, halibut, eels, mackerel, whitefish, perch, bluefish, and shad.[3] The custom of allow-

[1] Experienced poulterers and butchers claim that every variety of fowl and game has its particular season, and at such times the flesh, even of old birds, will be found tender and palatable, just as fruit eaten in season is far preferable to that which is forced for an early market.

[2] Investigations show that in the United States generally from one-half to two-thirds of the protein of the food is obtained from animal sources, *i.e.* meats, milk, eggs, and fish, but that less than 5 per cent is furnished by fish. "Laborers employed in the fisheries of Russia consume from 26 to 62 ounces of fish daily. This, with some bread, millet meal, and tea, constitutes the diet throughout the fishing season. These quantities are unusually large, but no bad effects are mentioned as following the diet. There is a widespread notion that fish contains large proportions of phosphorus, and on that account is particularly valuable as brain food. The percentages of phosphorus in specimens thus far analyzed are not larger than are found in the flesh of other animals used for food. But, even if the flesh be richer in phosphorus, there is no experimental evidence to warrant the assumption that fish is more valuable than meats or other food material for the nourishment of the brain." — C. T. Langworthy, Ph.D. (United States Department of Agriculture), *Fish as Food.*

[3] Fish such as the skate and sea-robin, known to be wholesome, are seldom eaten, owing to prejudice.

ing fish to die slowly, when caught, is not only inhuman, but it also lessens their food value.

All fish are best when in season, and should be selected with care. The freshness of a fish is determined by the fulness and brightness of the eyeballs, and the vivid color of the gills. The sense of smell cannot always be relied on in selecting fish, since packing in ice prevents, to a large extent, the escape of odor.

Shell fish and the flesh from the hind legs of frogs are valuable edibles, though some of these foods at times prove more or less indigestible, and excite reddening and an almost unbearable itching of the skin, known as "hives" or "nettlerash"[1] (*a*).

217. Harmful Meat. — Though meat partially decomposed may be eaten with apparent impunity by some persons, in the majority of cases it either causes indigestion and severe sickness, or deteriorates the system so that it easily succumbs to infectious diseases (*a*). It sometimes happens, notwithstanding the vigilance of health authorities, that unwholesome meat is sold in the shops. Therefore it is important that buyers should know what constitutes good meat (*b*).

Meat eaten raw, or but just warmed through, may prove dangerous to health from the trichinae or other animal parasites it sometimes contains.[2] This is especially the case with pork and fish. Certain diseases of animals, such as glanders, splenic fever, and tuberculosis of cattle and

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[1] Fish should be fresh and well-cooked. Oysters obtained where filth abounds should never be eaten, as they are apt to contain harmful bacteria.

[2] Parasite poisoning generally occurs in people who have eaten raw or underdone meat, in sausages, pork or veal pies, or from the inner parts of a roast. A heat of nearly 212° is necessary to destroy parasites.

hogs, render their meat dangerous. Meat should be cooked enough to coagulate its albumin and blood, develop its flavor, kill bacteria, and render it tender. Overdone meat is generally more or less insipid and indigestible.

218. Milk is an emulsion of fat (*i.e.* cream) in water, and contains albumin casein, sugar, and salts. Many persons consider it only a beverage, whereas it is an important article of diet, even for adults, since it contains all the necessary food elements in the most digestible form. It sustains the life of infants at a time when the digestive organs are most sensitive. It should be the principal food of children. Contrary to a popular belief, milk is of decided value in fevers and many other ailments. Persons with whom milk does not agree, or whom it is said to make "bilious," will often be able to digest it if it is taken in small quantities hot, or fresh from the animal, or with the addition of lime or seltzer water.[1]

Milk is sometimes deprived of its cream, diluted with water, or otherwise adulterated by dishonest dealers.[2] It is also capable of absorbing noxious odors and emanations, and may convey the infection of scarlet and typhoid fevers from infected milk rooms. Even the very best milk is so susceptible to change, that a thunder storm, or exposure to

[1] For an adult to obtain, from milk alone, 3500 calories fuel value, it would be necessary to consume a large quantity per day, and this would furnish too much water and protein. Goat's milk is a good substitute for cow's milk, though not so readily digested.

[2] Milk may appear rich (owing to its cream, or fat, which rises to the surface), and yet be deficient in albumin and salts. In large cities, unwholesome milk is largely consumed by the children of the poor, to the exclusion of other food, and is responsible for many deaths among them.

the heat of the sun, or contact with the smallest particle of sour milk, may render it unfit for use.

Great care should be observed in milking and in the keeping of milk (*a*). The store rooms, as well as the vessels which contain it, should be clean and free from odors. The udder of the cow should be cleansed before milking, and the hands of the milker should be clean. The milk from healthy animals only should be used. Tuberculosis is too frequently spread among human beings by the milk of consumptive cows.

Buttermilk, or milk deprived of most of its fat in the process of butter-making, is a wholesome drink, pleasant for summer use. It is sometimes prescribed for invalids. *Skim-milk*, or that from which the cream has been in part removed, is more valuable than buttermilk, as it contains more of the various ingredients of milk. *Whey*, or milk from which most of the casein has been removed in the process of cheese-making, is readily digested, even when slightly sour, and can be made palatable by the addition of a little nutmeg and sugar.[1]

219. Butter is an important food, if fresh and sweet, and is considered the most digestible of animal fats, as it is the most palatable; but it is expensive. It consists principally of the fat of milk, with water and a small quantity of casein and salts. Artificial butters, such as

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[1] In referring to buttermilk, Dr. Chambers says, "It is refreshing and nutritious, and to see it given to pigs, instead of being distributed to the neighbors, makes the philanthropist's heart bleed." "Some think that skim-milk is worth very little, and buttermilk still less, whilst they give whey (if at all) only to the sick. This is a very great mistake, and the poor should get all the buttermilk and skim-milk they can obtain; they may be purchased when new milk cannot be afforded." — EDWARD SMITH, *Foods*.

oleomargarine and butterine, are made of animal fat, with perhaps a trace of butter. If the fat is fresh and clean, these substitutes have practically the nutritious value of butter. Marrow, olive oil, cottonseed oil, and the crisp fat of cooked bacon or beef are also good substitutes for butter.[1]

220. Cheese contains the nitrogenous elements as well as some of the fat of milk, in a concentrated form. It is a valuable food, if eaten in moderation and combined with starchy articles of food. Soft cheese, such as is used largely in Europe, and new cheese are in general most digestible. Old cheese in small quantity is an appetizer. Skim-milk cheese is almost pure casein and hard to digest.

Cheese should not be eaten in large quantities by any one, and for children and persons with weak digestion a very small amount should suffice. Very young children should never eat it.

221. Eggs consist of water, fats, albumin, and salts. They afford much nourishment, and may occasionally take the place of meat. They are most digestible when soft boiled, or in omelets, or incorporated with starch or flour in plain puddings.[2] The yolk of eggs, boiled hard and powdered very fine, is digestible, but hard-boiled eggs do not agree with most persons.

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[1] Beef suet, if chopped fine, combines well with bread, rice, etc., in puddings, and affords fat in a digestible form.

[2] Eggs as ordinarily fried are particularly hard to digest. A poached egg, in which the albumin is coagulated to a bluish white color, is readily digested. So also is an egg broken into a hot dish (containing a piece of good butter) over a hot fire, and served when just coagulated.

222. Vegetable Foods include the cereals, or bread-stuffs, garden produce, and fruits.

The *cereal grains* most commonly used as food are wheat, barley, oats, corn, rye, and rice. Wheat is rich in nitrogenous matter, salts, and starch, and is generally considered to be, among the cereal foods, — like beef among meats, — the foremost in nutritive value. Barley ranks next. Rye, though containing a large amount of nitrogen, is not as a rule so readily digested as wheat and barley. Oatmeal and corn contain much nitrogen and more fat than the other cereal grains, and are valuable to persons not troubled with weak digestion. Rice, though easily digested, contains a large amount of starch, and but little nitrogen; hence, to satisfy the appetite, it must be eaten in large quantity, if taken alone.

Cereals resemble each other, in that each kind consists of a starchy body inclosed in a skin or husk (sometimes of several layers), which, when detached from the kernel, is known as bran. Immediately beneath this husk is a layer rich in gluten, oil, and salts. The husk is generally woody, fibrous, and indigestible. When the husk is removed by any process, the whole grains may be used; in the case of oatmeal or wheaten grits, the grains are simply crushed; in that of wheaten flour, they are ground fine. The finest and whitest wheat flour often contains much starch and but very little gluten. Flour best adapted for family use is that which has a slight yellowish tinge, is not very fine, and contains sufficient gluten to form a coherent ductile dough when mixed with a little water.[1] It will make darker

[1] The old-time custom of squeezing the dry flour in the hand, for the purpose of testing the proportion of gluten as shown by its cohesive qualities, will not hold good with flour made by the "new process"; and even

looking bread than pastry flour, but is sweeter and more nutritious.[1]

223. **Bread** is ordinarily made from wheat flour, since other flours do not contain sufficient gluten to make a dough through which gas can permeate to make light bread. Rye, maize, and oatmeal may be combined in varying proportions with wheat flour for various kinds of bread. Good bread may well be called the "staff of life," the only nutritious element deficient in it being fat. This is commonly supplied by butter or oil.[2]

Hot, poorly cooked, or very moist bread is not digested with ease. Leavened bread, *i.e.* bread made light and spongy by means of carbon dioxide distributed through the doughy mass, is much more easily digested than unleavened bread, such as pilot biscuit and hardtack, which are merely mixtures of flour, water, and salt. Leavening is generally effected by means of a fermentation generated in dough by yeast.[3] Carbon dioxide, forced through dough by machinery, makes what is called "aerated bread." This gas is generated in the making of bread,

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the test of pulling the moist flour between the fingers does not always prove true. In fact, the only absolute proof of good flour seems to be in the cooking, though it is said that flour rich in gluten takes up a great deal of water in proportion to its bulk.

[1] Oatmeal and barley are sometimes not relished, because of a burnt taste given in the process of kiln drying, or a musty odor and taste from having been kept in a moist state. "The steam-cooked cereals," being partly cooked, are easily prepared for the table, and, owing to the partial change of starch into dextrine, are quite readily digested. Rye should be selected with care, as diseased or spurred rye — known as ergot — may cause severe sickness and even death. Mouldy maize is capable of producing a serious skin disease known as *pellagra*.

[2] Butter, therefore, is the "golden head" of the "staff."

[3] It may also be effected by a piece of fermented dough.

biscuit, etc., by the proper combination of soda and cream of tartar, or other substances. Graham bread[1] is made of unbolted wheat flour. Such bread is wholesome, but contains so much bran that it should be eaten with caution by persons of weak digestion.[2]

224. **Vegetables** are furnished by our best markets in greater or less variety throughout the entire year.[3] Notwithstanding this supply, they are comparatively but little used, or certain kinds are used to the exclusion of others (*a*). No vegetable is more useful than the white, or so-called Irish, potato (*b*). It may well be called the king of vegetables, for it agrees with the majority of persons, and can be obtained in every season of the year. And yet hardly $2\frac{1}{10}$ of its 25 per cent of solid matters is nitrogenous. Potatoes are deficient also in fat and salts, and should be eaten with butter and salt, pot liquor, meat gravy, or fat meat. They resemble rice in the large amount of starch they contain, and, like rice, must be consumed in considerable quantity if they form the main ingredient of the diet.[4] Mapother claims that the almost exclusive reliance upon the potato in certain parts of Ireland has depressed the spirit and energy of the inhabitants, and he urges them to raise and use more of other vegetables.[5]

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[1] Named after Mr. Graham, the founder of so-called "Grahamism."

[2] The brown bread made of flour from which bran is almost entirely excluded is readily digested.

[3] About 50 different kinds of vegetables are for sale throughout the year, in the large public markets of cities, yet most families use but 12 or 15.

[4] Potatoes, peeled and soaked in cold water before boiling, lose one-fourth of their albuminoid material, besides much mineral matter and nearly 3 per cent of their carbohydrates.

[5] Mapother undoubtedly refers to the poorest classes, who cannot obtain sufficient nitrogenous food, — even milk to use with their potatoes, — and who are also depressed by the want of variety in food.

Sweet potatoes, though not quite so digestible as white, are wholesome. The yam varieties, which are eaten so much in warm countries, are sometimes mixed in corn meal bread. Beets, carrots, parsnips, onions, leeks, oyster plant, squash, and other vegetables are valuable additions to the table.[1] Potatoes and onions, together with fresh salad vegetables, — such as tomatoes, cabbage, greens, lettuce, celery, corn, and cucumbers, — are excellent preventives of scurvy, as we have already seen; and in the spring their juices and salts are eminently beneficial[2] (*c*).

Peas, beans, and lentils contain considerable starch and a large amount of albuminoid material. When dried, they are not easily digested by persons leading a sedentary life. Yet, on account of the ease with which they can be transported and preserved, these foods are valuable wherever large numbers are to be provided for. As is the case with some other vegetable foods, they require more thorough cooking and mastication than meat, though there is a popular belief to the contrary[3] (*d*).

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[1] Carrots and some other vegetables are considered by many persons as fit only for cattle; but if the same attention was paid to their preparation and cooking as is spent upon other foods, they would be considered delicious.

[2] Such vegetables, together with fruits, are preferable to sulphur and molasses, or so-called "spring medicines."

[3] The statement credited to General Scott, viz., that "Beans have killed more soldiers than bullets," has been misunderstood. The bad effects following their use by soldiers have been due mainly to their being insufficiently cooked. The red native bean of the tropics, like the white bean of this country in shape, is to be tried for our soldiers in hot countries. Its hull is thinner, and the bean is broken up more thoroughly by cooking than the white bean. It is more readily digested, and does not irritate. "This bean, together with the tortilla, practically made from hominy, forms almost the entire diet of the Mexican army, and there are few, if any, soldiers who can endure greater fatigue, or among whom is less sickness from dietary causes."

225. Fruits are particularly esteemed for their juices, which consist of water, sugar, and vegetable acids (*a*). They are most wholesome when eaten in season in the part of the country where they grow.[1] Over-ripe or under-ripe fruit may be harmful. Bacteria flourish on unclean fruit. The quantity of albuminoids contained in fruits is generally very small.[2] Fresh fruits serve to quench the thirst, to supply acids, sugar, etc., to stimulate the appetite for more substantial food, and to assist in its digestion.[3] Grapes, peaches, oranges, strawberries, cherries, blackberries, raspberries, plums, bananas, apples, pears, and apricots are considered the most digestible. On the other hand, melons and other cold, watery fruits are likely to interfere with digestion, especially if eaten abundantly at meal times.

Fruit is said to be "gold in the morning, silver at noon, and lead at night." Cooked fruits may be eaten with benefit at any meal. Dried fruits, raisins, dates, etc., contain much sugar, and should be eaten in smaller quantity than fresh fruits.

Nuts contain a large amount of nitrogenous and more or less fatty material. They should be thoroughly chewed, and eaten in moderation.

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[1] Strawberries, for instance, which are brought to cities early in the year, are frequently ripened artificially, and contain much acid, which at times causes dyspeptic ailments.

[2] Bananas contain over 4 per cent, and furnish a valuable food, if they are naturally ripened and are eaten in moderation.

[3] "In hot climates these refreshing fruits grow in great abundance, and render a residence in the tropics tolerable. A slice of melon or other fruit is the common gratuity given in addition to the regular charge for any service in hot climates, and forms a contrast to the lump of fat which is its equivalent with the Esquimaux."—FOTHERGILL, *Maintenance of Health.*

226. Condiments are substances which sharpen the appetite, give a relish to food, and stimulate the digestive organs. Of these, salt, pepper (especially the red), mustard, vinegar, ginger, and horse-radish are the most important.[1] Pickles, olives, lemon juice, and sauces also belong to this class of accessory foods. An immoderate use of condiments is injurious, for it causes the consumption of more food than the system requires, and perverts the appetite. Savory herbs, such as sage, thyme, and parsley, make certain foods palatable, and can often be substituted with advantage for more stimulating condiments (*a*).

227. Water. — Drinks may be divided into natural and artificial. The first class includes water and milk; while the second embraces tea, coffee, cocoa, and alcoholics.

Water is in reality the most important of all foods, as it is a necessary constituent of all parts of the body (*a*). Pure water, chemically speaking, consists only of hydrogen and oxygen. It is probably never found in nature, but may be obtained by distillation. It has a flat taste and is not palatable. Rain water, especially that which falls at the end of a shower, is nearly pure, and is more palatable than distilled water, on account of the air which it contains.

228. The *best drinking water* is that which is clean, soft, colorless, without odor even after boiling, and which has just enough salt, air, and carbon dioxide in it to make it palatable. Water may be clear and sparkling, and still

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[1] "Hard work and attendant good appetite require little else than common salt as a condiment, which should be plentifully used. It was said by Plutarch that *hunger* and *salt* were the only sauces known to the ancients; and the very word 'sauce' is derived from the Latin word *salsus*, 'salted.'" — McSherry, *Health, and How to Promote It.*

be impure and dangerous. This is especially the case in well water that has filtered through graveyards or soils polluted by cesspools, barnyards, etc. That dirty-looking waters are not necessarily unfit for drinking is shown by the fact that the muddy water of the Mississippi is drunk with impunity by those accustomed to it.

The green scum found on ponds and along the edges of some streams consists mainly of plants of low organism, such as algae. In small quantity they are not injurious; but if luxuriant, their growth indicates the presence of organic matter which is hurtful. If they die and decay, they tend to spoil the water (*a*). Water from melting ice is usually purer than that from which the ice was formed, for freezing is a purifying process; but ice from stagnant ponds, or from water which contains much organic matter, is unfit for use. Whenever there is reason to believe that water is unwholesome, it should be examined, both microscopically and chemically, by competent persons (*b*).

229. Sources of Drinking Water. — Good drinking water is usually obtained from rivers, lakes, deep wells, and springs. Water from shallow wells, the surface of the ground, and most brooks should not be used for drinking purposes. In places where the water supply is not abundant, *rain water* may be used for drinking, if carefully collected and filtered; but if allowed to run over dirty roofs, or over decaying leaves and other vegetable growths, it acquires an unpleasant taste and may prove hurtful. Probably the best form of drinking water is good spring water, — that is, from rain or snow, which, after filtering through rocks and gravelly soil, gushes forth clear and sparkling into the air (*a*). Water from deep wells, fed

as they are by underground streams, is much purer than that from shallow wells, which is largely the drainage from the upper or impurer layers of the soil and has less chance of being thoroughly filtered by percolation through a great depth of soil.[1] Examples of deep wells are artesian and driven wells,[2] and such immense wells as those at Garden City, L.I., and at Prospect Park, Brooklyn. Some of these wells furnish millions of gallons of drinking water daily.

230. Hard and Soft Water. — Ordinary drinking waters usually contain, in various proportions, common salt, sodium, lime, magnesium carbonates, and air, as well as carbon dioxide, which last gives a sparkling appearance and an agreeable taste to water. Mineral waters contain, in addition, other mineral ingredients.

Water containing an excess of salts, especially of lime and magnesia, is known as *hard water*. It makes the hands feel rough. Water containing little or no lime and magnesia is *soft water*. The hardness may be temporary or permanent; if temporary, it is due to calcium bicarbonates and magnesium bicarbonates, which may be precipitated by boiling, thus rendering the water soft and suitable for drinking. If permanent, the hardness is due to calcium sulphate and magnesium sulphate, which can-

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[1] Examinations made from time to time of the water from shallow wells, in cities and towns, have shown it to be frequently contaminated by filth from cesspools and other sources, which in many instances were but from 25 to 30 feet distant, and sometimes on a higher plane than the wells. According to good authorities, they should be at least 100 feet away from drinking wells.

[2] Artesian wells vary in depth from one to three or more thousand feet. Such wells are used in abattoirs, breweries, and other large establishments, where larger quantities of water are needed than can be furnished by the ordinary water supply of cities.

not be precipitated by boiling.[1] Hard water is not suitable for cleansing purposes, as it forms, with the fats of the soap used, an insoluble compound, which floats as a scum upon the surface of the water.[2]

231. Impure Drinking Water. — Stagnant water or that containing any decaying animal or vegetable matter is unfit to drink.[3] Sometimes water is a fruitful source of infectious diseases, such as typhoid fever and cholera, by reason of the disease germs which it contains, and which may be carried long distances in it. Impurities are more likely to continue in deep and sluggish streams than in brooks and shallow, active streams, where the water is more freely exposed to the purifying influences of the atmosphere. Yet the larger streams, on account of the abundance of water they furnish and the ease with which it can be obtained, are mainly relied upon for the water supply of cities and large towns. Water for drinking purposes should be taken from the middle of the stream and somewhat below the surface, as the refuse from factories, drains, and sewers, which finds its way to a greater or less extent into rivers and creeks, is most apt to flow along the sides.[4]

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[1] Hard water may frequently be softened by the addition of wood ashes, sodium carbonate, or borax.

[2] It is said that in Glasgow, by the introduction of water from Loch Katrine, the inhabitants saved in one year thousands of dollars in soap, the water used before having been very hard.

[3] The water of shallow wells and defective cisterns may cause malarial affections which are often credited to a marsh or mill pond near by.

[4] "The river Rhine, it is well known,
Doth wash your city of Cologne;
But tell me, nymphs! what power divine
Shall henceforth wash the river Rhine?" — COLERIDGE.

The answer is, — the oxidizing influences of the atmosphere. It has been shown that the farther away from the source of the impurities, the

232. The *mode of conveying drinking water* from its source of supply is a matter of great importance. Usually wood, lead, or iron pipes are used for this purpose. Rain water, or any water deficient in saline ingredients, flowing through lead pipes, may dissolve enough lead to render it poisonous. Saline ingredients in river, well, and spring waters, by partial decomposition, line the pipes with a crust, and generally prevent this absorption. Sometimes water, especially if hot, will dissolve enough lead to become injurious.[1] It is wise to let either hot or cold water run awhile before using it for drinking or cooking. Hot water running through iron pipes acquires a disagreeable taste. To obviate the risks above referred to, block tin pipes, tin-lined lead pipes, and glass-lined iron pipes are recommended by sanitary authorities.

Sometimes water that is kept in copper vessels absorbs copper and is harmful. The presence of iron salts in water in large quantity is undesirable. So, too, are alkalies, as in the dry region far west of the Mississippi River.

233. Purification of Water.—Water may be freed, by various methods, of much of its injurious matter. *Boiling* will destroy dangerous disease germs and precipitate the bicarbonate of lime and some of the coagulable organic matter. *Aeration* will render stale or confined waters palatable. Allowing them to settle will render some muddy waters

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better is the water for drinking purposes. This is true of ordinary organic impurities, but there is reason to believe that the germs of disease are not so readily rendered harmless.

[1] Lead pipes should not be used for soda-water fountains, as the carbonated water dissolves lead readily. The presence of lead in water may be detected by adding a few drops of a solution of sulphuretted hydrogen. If lead be present, it renders the water black, or dark brown, owing to the sulphuret of lead formed.

fit for drinking. This settling may be facilitated by previously stirring a little alum into the water. Proper *filtration* will partially remove not only suspended organic impurities, but even some dissolved ones. The filtrating substance may be porous earth, sand, charcoal, certain insoluble powders, fine gravel, sponge, etc., either alone or variously combined. Charcoal, oxide of iron, and sand are the most active. Filters act partly by sifting out solid particles, and partly by oxidation of the organic substances by means of the oxygen in the pores of the material used[1] (*a*).

234. Coffee and Tea neither form tissue nor act as fuel. In moderate quantity, they stimulate the nervous system, arouse dormant energies, tend to retard undue waste, and assist in the digestion of food. Hence they are best adapted for use after a hearty meal, but cannot take the place of food. As stimulants they are frequently superior to alcoholics, and have been found to be especially valuable in armies and on board ships, among soldiers and sailors exhausted by hard work.[2] They should not be used by

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[1] Suspected water in houses should be first strained through clean flannel, then boiled, and in summer kept in bottles in the ice box. Pipe-clay filters are serviceable, but, like all filters and strainers, must be kept clean, else they do more harm than good. "Probably the best filter is one composed of finely divided silicon and carbon, pressed into a solid cake. This filter, when dry and clean, will remove a large quantity of organic impurity, as well as lead, from the water passed through it. Prepared for soldiers' use, it was carried by the English soldiers in the late war in Egypt, and found to be of great service. Placed in even the dirtiest water, the fluid was sucked through the filtering mass by means of a rubber tube and mouth-piece, and was rendered fit for drinking."

[2] Rations of coffee are given with advantage to sailors in the United States navy and on some of the great ocean steamers, in place of their "grog." Coffee, more than tea, lessens the craving for alcohol. In the Spanish-American War, tea was of great benefit to soldiers in active service.

children, except when very much diluted with milk; nor should they be taken in large amount, or very strong, by any one. Thus taken, they cause the heart to act irregularly and depress the nervous system. If relied upon to supply, by their stimulating properties, the place of nourishing food, they produce indigestion.[1] Tea and coffee are similar in action, though they affect people differently at times. Each contains a volatile oil, which gives odor and flavor, an astringent (tannic acid), and an active principle — *theine* in tea, and *caffeine* in coffee.

235. **Chocolate and Cocoa** contain fatty matter, albuminous and starchy materials, and a substance similar to theine and caffeine, known as *theobromine*. They are not so stimulating as coffee and tea, but are much better as food. As Dr. Edward Smith remarks, in his valuable book on *Health*, "Perhaps few foods are so nutritious or will satisfy the appetite so well as cocoa and milk, if plenty of cocoa be used, and it is equally good for all ages, classes, and circumstances."[2]

236. **Alcoholic Beverages.** — While, as we have seen, malt liquors may contain some of the nourishing elements of the grain, and all alcoholic beverages in small amount

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[1] Investigations show that much of the ill health — viz. dyspepsia, bad feelings, and nervous ailments — among certain classes in this country and England is due to the excessive use of tea and coffee. Many women live upon tea and bread when alone throughout the day, rather than take the trouble to cook suitable food. Among the poor, tea is largely used, because it is considered by them cheap and nutritious.

[2] The fresher cocoa and chocolate are, the better. Cocoa, especially if retained in tight packages in close apartments, becomes musty; and, if exposed to the air for a long time, loses its flavor; hence, in some cities, it is freshly prepared every day by dealers. Unlike coffee and tea, there should be no grounds which cannot be eaten.

yield some energy to the body, they are likely to do so at the expense of working ability. Frequently their use is followed by depression, which, as a rule, is not the case with hot tea, coffee, cocoa, or soups. Neither do these, like the alcoholic beverages, produce a craving for more. When the system obtains food which is digested and is also sufficient for all the needs of nutrition, alcoholic beverages are unnecessary. The use of alcohol does not lessen the need of the healthy system for complete food, like bread, meat, and milk.

QUESTIONS.

1. How may foods be classified?
2. What do animal foods comprise?
3. Why is animal food frequently used to excess?
4. What meats are least digestible, and why?
5. What is to be said of poultry? Game? Fish?
6. Why should partially decomposed meat be avoided?
7. What are the reasons for cooking meat?
8. What is considered the "model" food, and why is it so called?
9. How should milk be protected from impurities?
10. Why are skim-milk, buttermilk, and whey useful?
11. What is said of butter and its substitutes?
12. What is to be said of cheese? Eggs?
13. What do vegetable foods include? What cereal grains are most used?
14. What is to be said of wheat and other cereals?
15. Which is the best flour for family use?
16. What kinds of flour are used for bread, and how is it raised?
17. Why are potatoes especially commended?
18. Why should other vegetables be used?
19. What is said of peas, beans, and lentils? What of fruits?
20. What are condiments, and how should they be used?
21. How may drinks be classified? What is to be said of water, and of the different kinds, and how may it be purified?
22. What benefit is derived from tea? Coffee? Chocolate and cocoa?
23. What is said of the use of alcoholic beverages in comparison?

CHAPTER XIII.

RESPIRATION.—ANIMAL HEAT.

237. Object of Respiration. — Blood, to nourish the tissues effectually, must contain oxygen. This is supplied by the atmosphere and by various foods, the largest amount being furnished by the air which we breathe. Simultaneously with the absorption of oxygen, the blood parts with its carbon dioxide and other impurities. This process is effected by *respiration*, or *breathing*.

238. The Organs of Respiration comprise the *lungs* and the *air passages* leading to them. Also concerned in the act of breathing are the ribs and their cartilages, the diaphragm, and those muscles of the chest which assist in expanding and contracting the chest walls.

239. The Air Passages include the interior of the nose, mouth, pharynx, larynx, trachea, the bronchi, and bronchial tubes. These passages not only afford transit for the air, but they serve also to warm, cleanse, and moisten it on its way to the lungs.

Though air enters the mouth to a greater or less extent, *the nose is the proper channel of respiration.* It is lined with mucous membrane, and is divided by a middle wall of cartilage and bone into separate nostrils, in each of which are three thin, projecting plates of bone, one above the other (Fig. 46). These curve downward, and are

covered by mucous membrane.[1] The air, therefore, in its passage through the nostrils, comes by a circuitous route into contact with a large extent of moist and warm mucous membrane. The membrane is kept moist by the secretions of its mucous glands, and warm by being richly supplied with blood.[2] In addition to these arrangements for warming the air, retarding its passage, and ridding it of dust, there are hairs just within the nostrils, and ciliated cells upon a part of the surface of the mucous membrane of the nose. Similar cells are also found upon the posterior surface of the soft palate, in the windpipe, and in other portions of the air passages. Their hairlike filaments are constantly vibrating, but with greater force in opposition to the entering current of air, or from within, outward. Their united movement somewhat resembles that of a field of wheat when moved by the wind. The effect of such an organism opposing itself to the entering air current is to catch foreign particles which may be intermingled with the air, and gradually carry them out of the air passages by an unceasing counter movement.

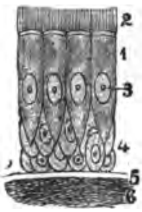

Fig. 79.

Diagram of a Vertical Section of the Bronchial Mucous Membrane.

1, ciliated epithelial cells. 2, cilia. 3, nuclei. 4, new cells. 5, basement membrane. 6, fibrous layer.

240. Mouth Breathing. — On the other hand, when we breathe through the mouth, foreign particles are forced into the throat and lungs and act as irritants, the mouth

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[1] These bones are known as the turbinated bones, from their fancied resemblance to tops.

[2] It is said that the nasal cavities are a degree or two warmer than the cavity of the mouth.

and throat become dry, and so imperative is the necessity for breathing that sufficient time is not taken for the mastication of food. In the habitual mouth breather, the nasal mucous membrane, being insufficiently used, dries and shrinks, causing discomfort.[1] The efforts that are necessary to breathe eventually result in unpleasant expressions of the face; the mucous membrane is likely to become more or less inflamed, and thus to obstruct the nasal passages; hearing is interfered with by partial or entire closure of the Eustachian tubes, whose function it is to convey air to the organs of hearing; the voice loses its resonance; and the lungs are imperfectly developed. Sometimes the tonsils enlarge, and obstruct the free movement of air through the nasal cavities and Eustachian tubes[2] (Fig. 46). If the trouble is long-continued in the case of babies and young children whose bones are deficient in mineral ingredients, there results, from the repeated violent efforts made necessary in breathing, more or less sinking of the lateral chest walls, thus causing an unnatural protrusion in front. This condition is popularly known as the "pigeon breast" (*a*).

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[1] Healthy babies breathe, for the greater part of the time, through the nose, with the mouth shut; and, if a baby is in the habit of breathing with the mouth open, there is reason to suspect the presence of enlarged tonsils, or some disease of the nostrils. A Scotch physician, fully appreciating the importance of proper breathing, has written a valuable medical paper entitled "Shut your Mouth and save your Life." We are told that some Indian tribes understand the importance of breathing through the nose, and that the squaw, before retiring for the night, sees that the mouth of her baby is shut. Some of the most careful trainers insist that walking and running should be, as far as possible, with the mouth closed.

[2] Enlargement of portions of the mucous membrane, behind the posterior nares, due frequently to chronic nasal catarrh, and known as "adenoid growths," are associated sometimes with mouth breathing. These growths should be removed by the surgeon, as they impair the voice, the respiratory power, and the general health.

241. The Larynx.—The pharynx, as we have seen, is a passage for air as well as food, but the larynx is for air alone. This latter organ is located in front of and adjoining the upper end of the oesophagus (Fig. 46), and opens into and is continuous with the trachea. It is composed of several cartilages controlled by muscles, and is so arranged as to form a kind of box. Near the middle of it is a dilatable opening called the *glottis*, through which respiration is performed, and by means of which articulate sounds are produced. Air enters the nose and mouth, passes through the pharynx, and thence into the larynx, trachea, bronchi, bronchial tubes, and the air-cells of the lungs.

242. The Trachea, Bronchi, and Large Bronchial Tubes, like the larynx and the air-cells, are lined with mucous membrane. They are tubes, kept open by a series of incomplete cartilaginous rings embedded in their walls and placed at nearly equal distances. These cartilages are bound together by strong connective tissue, and do not meet posteriorly,—an arrangement which gives the air tubes elasticity and pliancy, and in the case of the trachea allows the oesophagus to expand readily in swallowing.

The *trachea* is about an inch in diameter and four and a half inches in length, and has some muscular fibres in its walls. Before entering the chest, it is near the surface, and generally can be felt by the fingers. Nearly opposite the third dorsal vertebra it divides into two smaller tubes, the *right and left bronchus*.[1] Each bronchus

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[1] Bronchitis, or "cold on the chest," is an inflammation of the lining membrane of the bronchi and bronchial tubes, attended by swelling of the membrane and increased secretion of mucus. If this is considerable, the passage of air is impeded and difficulty in breathing results.

on entering the lung divides, like the branches and twigs of a tree, into *bronchial tubes*, which become smaller and smaller and finally end in *lobules*.

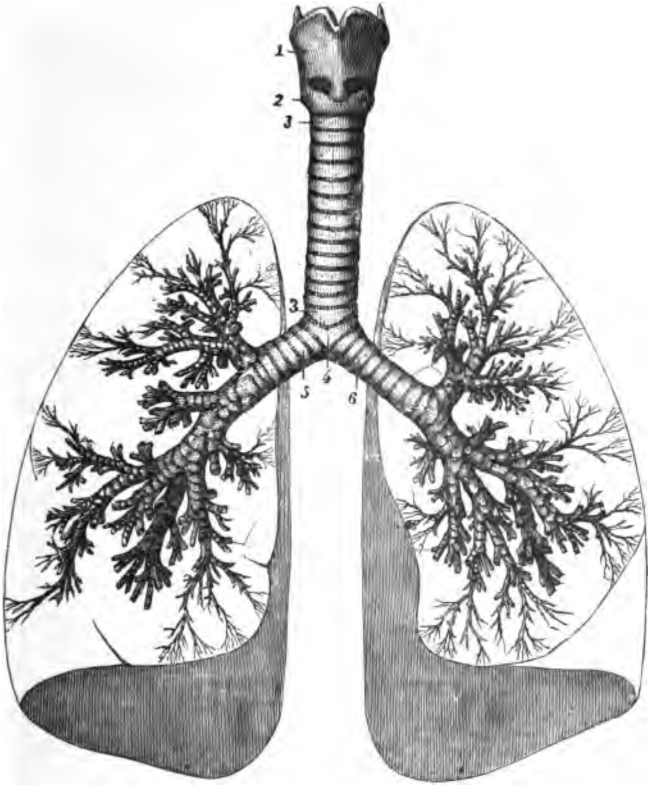

Fig. 80.

Lungs in outline, showing relations of the larynx, trachea, bronchi, and the bronchial tubes and their branches.

1, thyroid cartilage of the larynx. 2, cricoid cartilage. 3, trachea. 4, its point of bifurcation. 5, right bronchus. 6, left bronchus.

243. The Small Bronchial Tubes and the Air-cells. — The smallest bronchial tubes (*bronchioles*) contain no carti-

lages, but are delicate, elastic, and membranous, and have circular muscular fibres in their walls. The lobules, or dilated membranous terminations of these tubes, bound together by elastic connective tissue, are divided by the inward projection of portions of their walls into a number of pouch-like compartments, called *alveoli*, or air-cells. Each air-cell has very thin, elastic, and distensible walls, and is only about $\frac{1}{100}$ of an inch in diameter. Covering the lobules, and dipping down between the adjoining walls of the air-cells, is a close network of capillaries, intermingled with nerves and lymphatics. The capillaries are supplied by the pulmonary artery, and empty into the pulmonary veins. The convoluted arrangement of the walls of the lobules affords an extensive surface of very delicate membrane for the aeration of blood,—a surface much greater than that of the entire exterior of the body.[1]

244. The Lungs consist of bronchial tubes, air-cells, blood-vessels, lymphatics, and nerves, all bound together by elastic connective tissue. There are two lungs, located in the thoracic cavity, one on each side of the median line, and separated from each other by the heart and its great blood-vessels and by the bronchi. Each lung is cone-like in shape. Its upper end, or apex, extends about an inch above the level of the first rib.[2] Its

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[1] It is estimated that the extent of surface of all the sacs is about 2600 square feet, and that "in the course of twenty-four hours about 20,000 litres (35,000 pints) of blood traverse the capillaries, the blood corpuscles passing in single file and being exposed to air on both surfaces."

[2] This part is not inflated fully in mouth breathers, or by other persons having poor respiratory power, and is most susceptible to tubercular disease, probably because it is not actively used.

broadened lower surface is concave in form, and rests upon the upper convex surface of the diaphragm. The remaining surfaces of the lungs are convex in form, and fit into the concave interior of the chest walls.

Fig. 81.
Ultimate Bronchial Tubes and their Lobules. Connective tissue removed.

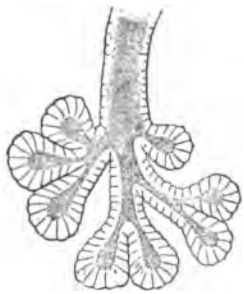

Fig. 82.
Lobules laid open, showing alveoli.

245. Movements of the Lungs.—*Free movements of the lungs are absolutely necessary for the full performance of their functions.* For this work they are well adapted by their structure and coverings, and by the arrangement and mobility of the chest walls. Covering each lung, except where the large blood-vessels and air tubes enter, is a strong but delicately constructed closed sac, known as the *pleural sac.* These sacs together constitute the *pleura.*[1] The space inclosed by each sac is the *pleural cavity.* One wall of each sac is closely adherent to the lung, and the other to the concave inner wall of the chest. The lining, or inner

[1] The word *pleura* is derived from the Greek, and means "rib" or "side."

surface, of each sac secretes in health just enough lubricating fluid to allow the inner surfaces of its walls to glide readily upon each other in the process of breathing.[1]

246. The lung substance is elastic, like a sponge, and is filled with inclosures containing air. If a piece of the healthy lung of an ox or sheep be pressed between the fingers, it makes a peculiar crackling, due to the partial dislodgment of air. If the piece be tightly squeezed, or even bruised between heavy rollers, sufficient air will still remain in it to cause it to float in water. In fact, the lungs are the only organs in the body that will float.

247. Mechanism of Respiration.—The process of respiration consists of *inspiration*, or breathing in, and *expiration*, or breathing out. Inspiration requires considerable muscular effort. The glottis is more or less widely opened, the chest walls are drawn outward and upward by muscles overlying the chest and by muscular fibres between the ribs,[2] and the diaphragm is made to descend by the contraction of its muscles. The thorax is thus dilated, and in consequence the elastic air sacs are filled with air forcibly sucked in. The normal enlargement of the thorax is in three directions; viz., vertical, from side to side, and from the back forwards. The first — due mainly to

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[1] When the gliding motions are hindered by the adhesion of the secreting surfaces of a pleural sac, as in pleurisy, anything more than the quietest breathing is attended with acute pain.

[2] There are two sets of muscular fibres between the ribs, placed diagonally and crossing each other, viz., the external and internal intercostal muscles. The first assists in pulling the ribs down, the second serves to pull them up. "The lungs lie in an air-tight chest with movable walls. When, by muscular contraction, the size of the chest is increased, the surface of the lungs must remain in contact with that of the chest; and air thus passively enters the lungs to occupy the increasing space."

the descent of the diaphragm, and the pushing outward of the walls of the abdomen — is the greatest, and is most common in men. It is often spoken of as "abdominal

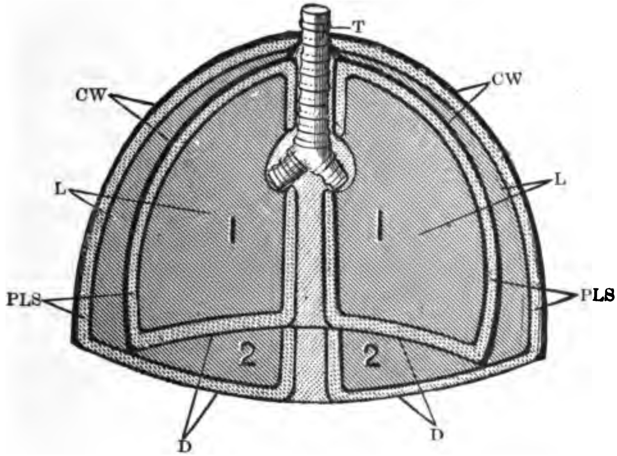

Fig. 83.

Diagram. Lungs in Inspiration and Expiration.—1, lungs contracted in expiration; 2, lungs expanded in inspiration.

T, trachea. L, the lung substance. D, the diaphragm.
CW, chest walls. PLS, pleural sacs (the walls separated).

breathing," or the "abdominal type of respiration," to distinguish it from breathing mainly by the elevation of the ribs, *i.e.* "costal breathing," or the "thoracic type of respiration."[1] This latter form of breathing is most common in women, especially those who take insufficient

[1] The action of the diaphragm in respiration may be illustrated with an open bell jar, whose lower and larger opening is covered by thin rubber. Place a snugly fitting cork in the neck of the jar, and through it put a glass tube, one end projecting above the opening of the neck, and the other end, with a thin rubber bag or pouch firmly secured to it, nearly midway into the body of the jar. If the rubber covering of the jar is pulled downwards, air will enter the tube at its upper end, and distend the bag (as in inspiration). Air will be forced out of the bag (as in expiration) when the rubber covering resumes its first position.

muscular exercise. The enlargement of the upper part of the chest is generally pronounced in women who restrict the free movements of the chest and abdomen by tight clothing. Indian women breathe as men do.

In both sexes, and at all periods of life, the free action of the diaphragm is necessary for health and energy. Though mainly composed of involuntary muscular fibres, the diaphragm is, to a certain extent, under the control of the will, and its strength, like that of the other respiratory muscles, can be increased by proper exercise, such as singing, reading aloud, oratory, etc.[1] Hiccoughing, sobbing, and laughter are occasioned by the spasmodic action of the respiratory muscles, especially of the diaphragm. Laughter, crying, and sobbing, though generally under the control of the will, may become violent and uncontrollable, as is sometimes witnessed in the anger or sorrow of children.[2]

248. Expiration immediately follows inspiration. It is a passive movement, and consists in the gentle expulsion of the air outward through the air passages, by the elastic recoil of the respiratory apparatus.[3] After each expiration

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[1] Physicians frequently meet with persons, especially those of sedentary occupations, whose breathing is shallow, the air-cells of the lungs expanding but very little. Oftentimes by proper exercise of the muscles of the chest and diaphragm (*i.e.* by so-called lung gymnastics), the respiratory power can be increased to a marked extent, and incipient disease of the lungs warded off.

[2] It sometimes happens that persons having the charge of children are very severe with them for sobbing persistently, when it is utterly out of their power to stop.

[3] By placing the ear over a healthy lung, we can hear the strong movement of the air as it enters the chest. Expired, it gives a low-pitched sound, as of a very gentle wind. Variations in the pitch, volume, and quality of these respiratory sounds, or "murmurs," enable the physician to detect diseases or disturbances.

there is a short period of rest. When more than ordinary respiratory efforts are necessary, as in oratory, singing, blowing upon wind instruments, etc., increased expiratory force is created, and the elastic recoil is aided by the powerful contractions of large abdominal muscles. These, pulling down the ribs and pressing upon the contents of the abdomen, push up the diaphragm, and thus squeeze out the air from the lungs. Corresponding inspiratory power results from a forcible contraction of the muscles of the diaphragm and of the respiratory muscles of the chest.[1]

249. The Number of Respirations varies from about forty per minute soon after birth to eighteen per minute in persons from thirty to fifty years of age. The rate is naturally more rapid where there is small lung capacity, when breathing rarefied air at great heights, or when taking exercise. Of course, where the opposite conditions exist, the rapidity is decreased.

250. The Quantity of Air breathed varies. In ordinary quiet breathing, during each act of respiration we inhale and exhale about thirty cubic inches of air (about a pint). This is called *tidal air*, because it is the ordinary amount which ebbs and flows in breathing. It is said not to penetrate, in such respiration, farther than the large bronchial tubes. But by the process known as gaseous diffusion, the heavier carbon dioxide in the air-cells and the vivifying and lighter oxygen in the bronchial tubes are intermingled, and the air in various parts

[1] In violent inspiratory efforts, following severe physical exercise, or when the action of the lungs is much impeded by disease, nearly all the muscles of the body may assist the respiratory muscles proper, by placing various parts of the body so that the respiratory muscles may have the best opportunities for work.

of the lungs is partially renovated. It is estimated that from eight to ten respirations are necessary to change the whole quantity of air in the chest cavity. Though about ninety gallons of air per hour pass into and out of the lungs in quiet breathing, such as is common among persons engaged in sedentary occupations, *continued tidal air breathing* is insufficient for the healthy development of the lungs. It does not meet the requirements of persons doing heavy work, nor is it suitable for any one if the atmosphere is vitiated by impurities.[1] For these reasons, among others, systematic exercise in the open air is important. After an ordinary expiration a healthy person can, by a forced effort, exhale from 75 to 100 cubic inches of air. This is termed *reserve* or *supplemental air*. There still remain in a healthy lung from 75 to 100 cubic inches of air that cannot be expelled. This is *residual air*. It is possible, by a forced inspiration, to inhale from 100 to 120 cubic inches of air in addition to the tidal air. This is known as *complemental air*.

251. The amount of air which can be forced from the lungs after the deepest possible inspiration constitutes the *breathing* or *vital capacity*. It is the sum of the reserve, the tidal, and the complemental air. It may be determined by an instrument known as the spirometer, and is found to be about 230 cubic inches in a person of average stature (5 feet, 8 inches); but the vital capacity is no

[1] Persons whose breathing is generally of this type—*i.e.* who have "shallow respirations"—have also a sluggish circulation, and are most likely to suffer from consumption and other lung diseases, especially if the air breathed is impure. Were it not for the increased amount of air carried into and out of the lungs at about every fifth or sixth act of respiration, such persons would suffer more than they do from the excess of carbon dioxide not eliminated.

evidence in itself of vitality, or endurance, or so-called "wind," for it bears a definite relation to stature, without being affected in a marked degree by weight or the cir-

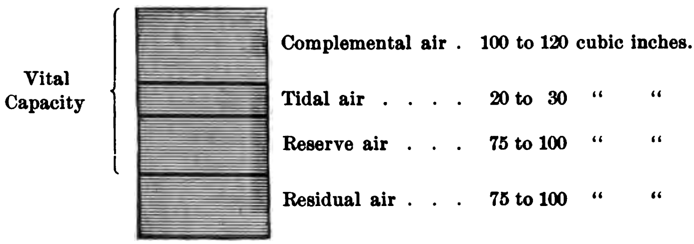

Fig. 84.

This diagram represents approximately the vital capacity, and the relative amounts of complemental, tidal, reserve, and residual air.

cumference of the chest.[1] It is diminished by severe thoracic and abdominal diseases; but the vitality of a person depends more upon the condition of the heart than upon the expansive capacity of the lungs.

252. Relation of Respiration to Circulation.—The movements of respiration are for the most part involuntary. From birth until death, asleep and awake, breathing, like the circulation, goes on involuntarily. There should be in adults one act of respiration to every four or five beats of the heart, and, in children, one to every three or three and one-half beats. But one can increase somewhat the rapidity of the respiratory movement up to his limit by

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[1] It has been shown by Hutchinson of England, who has made the most numerous investigations in this direction, and who makes the above statement, that for every inch in height between five and six feet, the vital capacity is increased eight cubic inches. It increases up to the age of thirty-five, and then diminishes.

various forms of exercise. With such increase, the heart's movements must increase proportionately, or exhaustion and suffering ensue from shortness of breath. On the other hand, the same effect is produced when the heart beats rapidly from severe exercise, and the movements of the lungs do not increase proportionately. Few persons can, without great effort, suspend respiration for more than thirty or forty seconds at a time. The desire for breath soon becomes imperative, owing to the circulation of blood of rapidly increasing impurity, especially in the lungs and brain. By breathing forcibly a few times, then taking a forced inspiration, respiration may be suspended for a minute, or even longer, thus enabling one to pass quickly through a cloud of dust, smoke, or other injurious matters in the atmosphere, or to remain for a short time under water.[1]

253. Changes in the Air and Blood during Respiration occur in the air-cells of the lungs. Through their thin walls, and those of the capillaries, simultaneously the oxygen of the air is absorbed by the blood, and some of the wastes of the blood pass into the air in the air sacs. *Inspired air* is robbed of a large part of its oxygen, and *expired air* is charged with noxious materials, and will not support combustion or maintain life. Animals and human beings obliged to breathe it exclusively soon die. It contains carbon dioxide[2] in excess, and small quantities of

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[1] This ability to hold the breath can be increased by systematic practice, as in the case of the so-called water kings and queens, who sew, write, and eat under water.

[2] The amount of carbon dioxide exhaled per day by a healthy adult is estimated at about 20,000 cubic inches, while the amount of oxygen consumed per day is estimated at about 40,000 cubic inches.

various excretory products similar to those excreted by the skin and kidneys;[1] also, an animal product which is offensive and prone to putrefy. It also differs from inspired air in that its temperature, especially in slow and tranquil breathing, is raised nearly to that of the blood, and because it contains an excess of watery vapor.[2] This vapor is especially noticeable when the breath is exhaled upon a mirror or window pane, or when it condenses in winter, as it issues from the mouth and nostrils.[3] Carbon dioxide is heavier than air, and is very poisonous to breathe. It constitutes about one twenty-fifth of the air that passes out of the lungs, and tends to make the atmosphere impure. The amount of carbon dioxide expelled is increased by exercise, and during and after a hearty meal. It is greatest in winter and damp weather, is especially abundant in the early morning, and is least at midnight[4] (*a*).

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[1] "Chloride of sodium, uric acid, and urates of soda and ammonia. It also sometimes contains carbonate and hydrochlorate of ammonia, and carburetted hydrogen and various odorous substances from the food and drink consumed."

[2] The air exhaled per day contains an average amount of nine or ten ounces of water, but the amount varies with the temperature of the atmosphere.

[3] In cases of suspected death, the condensation of the watery vapor of the breath upon the glass of a watch or a hand-mirror is an important evidence that life is still present in the body.

[4] The presence of carbon dioxide in the breath may be illustrated by the following experiment, which is all the more striking if tried after one has talked or sung awhile, or after a hearty meal. First, the gas, being *acid*, will change the blue color of a solution of litmus to red, when the breath is gently blown into the solution through a glass tube for a variable length of time. Second, that the expired air contains *carbon dioxide* will be shown by its changing clear lime-water, in the same manner as above, to a cloudy white liquid, due to the carbonate of lime formed.

254. The ancients believed that the function of the air, so regularly introduced into the lungs, was to cool the blood. But physiologists have ascertained that associated with the changes in the air, just studied, is the striking change in the color of the blood from blue in the pulmonary veins to scarlet in the capillaries of the lungs; and, also, that this change is due to the inhaled oxygen. If the breathing is seriously obstructed, the lips and face turn a purplish blue. If the obstruction is removed, the blood resumes its bright color, and the parts renew their functions. If the obstruction is not removed, the change in color is noticeable in other parts of the body, impure blood is circulated through the brain, and the individual becomes drowsy and unconscious, and death ensues. There is constantly going on in the blood a double change,—a loss of oxygen and a gain of carbon dioxide in the tissues, and a loss of carbon dioxide and a gain of oxygen in the lungs.

The urgent appeal of the lungs for pure air, when the breathing has been carried on in an impure atmosphere, or where the lungs are in a diseased or abnormal condition, is like the appetite for food on the part of the digestive organs. The cry originates in the tissues, which demand in the one case the food and in the other the oxygen, both of which are necessary to life.

255. Nervous Control of Respiration.—The movements of the diaphragm and the respiratory muscles of the chest are controlled by nerves. The impulses which stimulate these nerves to action originate in a part of the brain known as the *respiratory centre.* If this centre is destroyed, breathing stops, never to be renewed. Its activity seems to depend largely upon the condition of the

blood which circulates in it. The poorer the blood, the greater is the effort required on the part of this nerve centre to insure increased activity of the respiratory muscles.

256. **Relation of Circulation, Respiration, and Animal Heat.** — The changes which living tissues undergo in the production of animal heat are especially indicated by the absorption of oxygen and the exhalation of carbon dioxide. The more rapid the respiration and circulation, the higher is the temperature. On the other hand, if the temperature of the body is lowered by insufficient food or the use of alcoholics, and secretion and other processes are interfered with, respiration and circulation, at first accelerated, are gradually lowered below the normal standard. Animal heat remains in the body for a variable period after the blood has ceased to flow and respiration has stopped.

257. Exposure to moisture and a high degree of heat, especially if accompanied with exercise, is apt to cause death, which is then said to be the result of sunstroke, or heatstroke.[1] The old, the feeble, and the inactive are most affected by high temperatures, and in them also animal heat is maintained at its normal point with the greatest difficulty. With them the blood circulates more slowly, respiratory power is decreased, the chemical and mechanical processes take place less rapidly, and heat is generated in smaller amount than in robust health. "Thence it is," says Bennett, "that the old man seeks the sun, and that we find him in the country sitting at his door for hours,

[1] No case of spontaneous combustion — *i.e.* the rapid destruction of the human body by fire, as the result of excessive animal heat — has been proved, though sometimes reported.

basking in the sun, seeking from its genial rays the warmth which the organic processes no longer afford, as in former days—the days of his youth and of his organic vigor."

258. In summer and in hot countries perspiration and a decreased amount of clothing moderate the animal temperature; in cold climates and seasons the heat of the body is preserved by extra clothing, by warming the atmosphere with artificial heat, by more exercise, and by an increased amount of food. It is the testimony of many observant travellers, that the health of persons journeying from one climate to another is best preserved when the customs of the inhabitants of these climates are followed, in regard to food, exercise, and clothing (*a*).

259. Effects of Alcohol and Narcotics on Respiration and the Respiratory Organs.—In habitual drunkards, the blood is practically an alcoholized fluid. Part of the alcohol is excreted by the lungs, kidneys, and skin, and part is broken up in the blood into other substances. Such blood tends to congest the capillaries of the lungs, and by getting rid of an undue amount of heat, to produce a sensitiveness of the lungs to cold, which is quite frequently followed by obstinate attacks of bronchitis. Repeated congestion of the lungs, by thickening their lining membrane and thus interfering with the diffusion of gases, retards the change of impure blood into pure blood, and permits carbon dioxide to be retained in undue amount. The heart is compelled to work harder to overcome the obstacle to the free propulsion of its contents.

Probably one of the most constant effects of alcohol and alcoholic liquors, especially in considerable amount, is to produce a depression of both rate and depth of

respiration through direct action on the respiratory nerve centre, and to diminish the exhalation of carbon dioxide. This substance, retained in the blood and tissues, produces a feeling of depression. For the oxidation of alcohol in the body, some oxygen is consumed, which otherwise would be used by the food and tissues.

260. The evil effects of *tobacco*, either chewed or smoked, are due mostly to nicotine. Tobacco smoke, however, sometimes acts as an irritant to the throat, nasal passages, larynx, and Eustachian tubes, producing either an obstinate catarrh, or a very dry condition of the throat, known as "smoker's throat." This is attended by coughing, hawking, and expectoration, and, when the Eustachian tubes are inflamed, produces deafness also. These bad results are most likely to occur when tobacco smoke is inhaled, and are common among cigarette smokers, of whom it is estimated about 90 per cent inhale the smoke.

261. The local effects of *opium* and other narcotic drugs upon the respiratory organs is usually to diminish their secretion of mucus, and so interfere with their functions.

QUESTIONS.

1. What is the object of respiration, and what are its organs?
2. Describe the lungs. How are their free movements secured?
3. Name the air passages and their four functions.
4. Describe the nose, and its advantages over the mouth as an air passage.
5. What are some of the evils of mouth breathing?
6. With what passage do the nasal cavities connect, and what tubes and glands are there located? State the object of the tubes.

7. What is situated below the pharynx, and of what air passage is it the commencement?
8. Describe the larynx; the trachea; the bronchial tubes; the lobules.
9. How are the trachea and other air tubes kept open? How the smaller tubes?
10. Why do these tubes terminate in convoluted lobules, and what blood-vessels are there placed?
11. Of what does the mechanical act of respiration consist? Describe each process.
12. What may aid powerful respiratory efforts? Describe the action of the diaphragm.
13. What connection has the will with respiration? the heart? the condition of the blood?
14. Explain what is meant by tidal air; by residual air; by reserve air; by complemental air; by vital capacity.
15. What changes take place in the air during respiration? in the blood?
16. Where does the appeal for fresh air originate, and how is the needed oxygen supplied through the lungs?
17. By what nervous influence are the respiratory movements effected?
18. What are the relations between respiration, circulation, and animal heat?
19. What are the effects of alcohol and narcotics upon the lungs and respiration?

CHAPTER XIV.

AIR. — VENTILATION. — LIGHT.

262. Relation of the Body to Atmospheric Pressure. — So well is man adapted to the *atmosphere*, that its density cannot be much increased or diminished without interference with the circulation, respiration, and other vital processes. The thickness of the atmosphere is supposed to be not less than 45, and not more than 200 miles, and the pressure of this immense mass at the sea level is computed to be 15 pounds upon every square inch of surface. Upon the body of a man, therefore, of average size, it is more than 16 tons. This pressure, enormous as it appears, is of vital importance to the animal economy. At great heights, where atmospheric pressure is diminished, breathing becomes exceedingly difficult, or impossible. Not only does the rarefied air not furnish sufficient oxygen to the lungs, but carbon dioxide is imperfectly eliminated, and owing to diminished pressure upon the blood-vessels, bleeding may occur from the nose, mouth, and ears.[1]

In deep subterranean and submarine excavations, such as mines and tunnels, the atmospheric pressure is so increased that the workers in them are often disabled. Sometimes in the construction of the piers of such large bridges as that over the East River, between New York and Brooklyn, it is necessary to sink an immense inverted

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[1] "At an altitude of a little under 11,500 feet, we find that the pressure is only two-thirds of that at the sea level."

box, or caisson, in which men work, digging out the earth for the foundations. As the earth is excavated, the caisson sinks, and the air which it is necessary to pump in becomes exceedingly dense, as its pressure equals the pressure of the water without.[1] Such dense air is as injurious as exceedingly rarefied air, producing severe neuralgic pains, great prostration, hemorrhages, or paralysis.

263. Composition of Air. — Atmospheric air is in general a mixture of one part in bulk of oxygen to four parts of nitrogen, associated with a varying quantity of carbon dioxide, ammonia, watery vapor, inorganic and organic matter. The amount of carbon dioxide is usually very small at ordinary elevations, — only about four parts in every 10,000 of air. It is utilized by vegetation, most of the carbon being solidified in the vegetable tissues. Its presence in the atmosphere is shown by the film of carbonate of lime that forms upon lime water when exposed to the air. The amount of ammonia is usually about one grain to 23,000 cubic feet of air. It emanates from putrefactive processes in progress on the surface of the earth, and is also produced from the nitrogen of the atmosphere by electric agency during thunder storms. It furnishes to vegetation nitrogen, much of which is consumed by, and enters into the tissues of, animals.

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[1] "Caisson disease" seriously impaired the health of the chief engineer of the East River Bridge, and also that of some of the workmen. At the St. Louis Bridge, when one of the caissons touched a rocky bed, the atmospheric pressure was 45 lbs. to the square inch, and by the rise of the river it was increased to 50 lbs. When the pressure was 34 lbs., severe suffering began. It was found that the men could work only one or two hours at a time. They were generally taken sick on coming out of the air-lock into the normal atmosphere, seldom in the air-lock itself. This sudden exposure to air at the normal pressure was "equivalent to the application of a gigantic cupping glass to the whole body."

The amount of watery vapor depends largely upon the temperature of the air. It seldom forms more than $\frac{1}{80}$, or less than $\frac{1}{200}$, of the bulk of the air, and preserves the general purity of the atmosphere.[1] If in considerable amount, it prevents desiccation, and maintains the vitality of organisms submerged in it. Inorganic matter and vegetable and animal organic matters are found in most specimens of air examined, the amount varying in different localities. Rain, called sometimes the sewage of the atmosphere, carries to the earth these and other substances, which otherwise would accumulate without end. The clearness of the atmosphere after a rain storm is a matter of common observation.

264. Oxygen and Nitrogen. — *Oxygen*, as we have seen, is necessary to purify the blood and sustain life. Animals usually die when the quantity of oxygen in the atmosphere is reduced from three to five per cent. Without it, combustible bodies would not burn. Just as we find the most valuable food constituents become less valuable when used alone, so oxygen requires to be diluted with the other ordinary constituents of the air, in order to become even respirable. Its dilution with *nitrogen*, which is a harmless, inert gas, is in the exact proportion which serves best to support life and to maintain that degree of combustion which is most useful to the ordinary purposes of mankind. Any diminution of its normal amount is

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[1] That water is present in the air is seen by its condensation in drops upon an ice-cold vessel — a pitcher or tumbler of ice-water — in hot weather; also in the dew, hoar frost, fog, rain, and snow, and in its effect on certain solid substances which have the property of combining with water and becoming liquid. Such substances, of which calcium chloride is an example, are said to be *deliquescent.*

attended with as bad results as is the addition to air of harmful substances. On the other hand, were the oxygen in excess, it would become a very destructive agent, in proportion to that excess. In such cases the tissues of animals would be rapidly consumed, together with all bodies having any chemical affinity for oxygen, and such as were set on fire would burn beyond control.

265. Ozone is a form of oxygen, but has greater chemical activity as an oxidizing agent than other forms; hence it is a powerful disinfectant, and is recommended for the purification of sick rooms. It exists in very minute quantity in the air, and, thus diffused, is considered a stimulating agent in debilitated conditions of the system. It is much more abundant in the country than in towns, and its quantity is increased just after a thunder storm.[1] Air highly charged with ozone is not breathable, and is capable of bleaching and destroying vegetable coloring matters.

266. Harmful Air. — *Suspended Matters.* It sometimes happens that air is rendered more or less injurious by the accumulation of dust and other suspended matters, or by an undue proportion of one or more of its normal constituents, or by the addition to it of poisonous gases.

A ray of sunlight in a darkened room, or in the open air upon a foggy day, reveals in its track myriads of shining particles of dust, however clear the atmosphere may otherwise seem. This dust consists, in varying proportions, of starch granules, cotton fibres, spores, seeds, pollen,

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[1] The quantity varies at different times and places, but it is said to be, at the most, about one volume in 700,000 of air, and is quite constant in the atmosphere among pine trees. Ozone passed through a mass of putrefying material will rid it of noxious odors.

and cellular tissue, of wool, hair, epidermal cells, and other animal substances, of flintlike particles, and of microscopic organisms in a living state.

From hundreds of sources suspended matters are wafted by the winds, and some of them are also carried by flies, mosquitoes, and other insects. They are found almost everywhere, even penetrating close joints of carpentry work. When in large quantity in the air, as at times in cities, they are irritating to the respiratory organs, especially of feeble people. In such cases it is advisable to protect the mouth and nostrils by a handkerchief or veil, or any other object through which the air can be breathed and which at the same time prevents the dust from entering the air passages.[1] In the same way the temperature of very cold air may be mitigated.

267. **Disease Germs** are at certain times wafted through the air, and are capable of producing dangerous infectious diseases, each according to its kind. Eight of these diseases, named in the order of their general prevalence, are: consumption, pneumonia, diphtheria, typhoid fever, scarlet fever, measles, whooping-cough, and small-pox. The relative importance of these diseases is shown by the following diagram:[2] —

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[1] In certain occupations, such as stone cutting, metal polishing, knife and glass grinding, or in white-lead works and other manufactories, the dust is so plentiful and irritating at times that "respirators" are worn, consisting of frameworks of wire gauze, made to fasten over the mouth and nostrils, containing a piece of sponge, cotton, wool, or other similar substance, slightly dampened.

[2] The *Teachers' Sanitary Bulletin*, No. 6, issued by the Michigan State Board of Health, from which the diagram was taken, states: "The mortality in Michigan is as low as that of any state of the Union, and much lower than in many states."

DEATHS IN MICHIGAN, 10 YEARS, 1887-96.

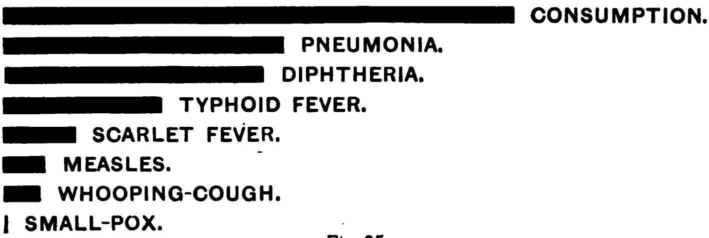

Fig. 85.

Disease germs retained in mud and upon moist surfaces may do no harm; but the mud of to-day is the dust of to-morrow, which will be scattered far and near, infecting the lungs of very susceptible people. Mud may also be a source of infection if brought into houses upon skirts and shoes. In buildings, conveyances, and in the streets, spitting should be refrained from, except into receptacles that can and will be disinfected. Dusting and sweeping should mean the *removal* of dust and dirt, and not merely its transference from one place to another.[1]

268. Consumption, once believed to be solely an hereditary disease, is recognized now as frequently the result of infection from specific germs in the sputum, or spittle, emanating from consumptives and mingled with the dust of the atmosphere.[2] Fortunately, the mortality from

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[1] Dusting is best effected by gently wiping surfaces with a slightly dampened piece of cheese-cloth. Moistened tea leaves, salt, oatmeal, or sawdust entangles dirt upon floors, so that it can be readily removed. Streets should be sprinkled before being swept. The amount of dirt or dust which accumulates each day in houses and schools is not generally appreciated. In one school, the janitor reports about one and a half bushels.

[2] "To examine the dust of the air microscopically, a small drop of glycerine, put in the middle of a glass slide, may be left lying, or be moved

this disease may be lessened, if its specific germs can be prevented from entering the air passages, and if infected persons can be isolated, breathe pure air, have proper food, exercise, and warmth, and be properly clad.

269. Observation of the diffusion of seeds of the thistle and other plants by the winds suggested that infection is spread by similar methods. The development of disease germs is believed to be as rapid as is that of the spores of the yeast plant. Both need for their development favorable conditions of warmth and moisture, the former, also a feeble human body, and the latter, fermenting material. Disease germs may lie dormant in cold weather, or where their surroundings are clean, only to grow and develop in the presence of moisture and filth, and may be carried long distances in merchandise and clothing, especially in woollen materials. They may be conveyed also by milk, water, insects, or mail matter. Children and feeble persons are most susceptible to their influence.[1] Quarantine —*i.e.* complete isolation and cleanly surroundings of persons with infectious diseases—will usually prevent the spread of infection[2] (*a*).

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for a given time against the air. Then a cover glass is laid upon this, and it is ready to be examined. Solidified flat surfaces of gelatine or other bacterial culture medium, exposed to the air for a time, and then covered and set aside for development of bacteria and moulds that may have fallen, give a fair idea of the varieties, and a rough, comparative idea of the numbers."—CURRIER.

[1] Disease germs are dangerous ingredients of the air of drains and cesspools, and only need the proper surroundings for their development.

[2] It is related that in the Scilly Isles, for ten consecutive years there was not a death from measles, scarlet fever, or small-pox, and only mild cases, if any at all, though such diseases were very prevalent upon the mainland. with which there was little communication.

270. Malaria. — The term *malaria* literally means "bad air." By physicians and sanitarians it is applied to malaise, or a diseased condition called intermittent or remittent fever. This condition is supposed to be due to impure air from low and swampy regions containing poisonous micro-organisms,[1] which come from vegetable matter in process of decay, but it may occur even in deserts. Malaria is often caused by the breaking up and overturning of soil not thoroughly drained.[2] The eucalyptus tree and the sunflower, on account of the power they possess of absorbing moisture by their roots, are valuable in drying the soil and preventing malaria (*a*).

271. The Organic Nitrogenous Matter which is thrown off from the lungs mingled with carbon dioxide and watery vapor, does much toward vitiating the atmosphere. Its exact composition has not been ascertained. It has a disagreeable, persistent odor, and is known to be poisonous.[3] Combined with the emanations from the skin and other impurities, the mixture gives to the atmosphere of a crowded room that odor which is so disagreeable to those who enter the room from the outer air. It is also the cause of that close, oppressive sensation perceived so often in the unventilated rooms of tenement houses.

Air containing such ingredients ordinarily acts as a

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[1] These cannot be cultivated artificially like bacteria, hence less is known of them.

[2] The deep upturning of the ground, as in the building of large sewers and displacement of muddy soil to construct railroad beds, has produced malarial poison in localities where it had not been before.

[3] In an experiment by Dr. Hammond, a mouse confined in an atmosphere of carbon dioxide breathed with difficulty. When some of the organic matter was removed from the atmosphere, although the air was still loaded with carbon dioxide, the mouse breathed more freely.

subtle poison, undermining the health, and changing the character of the blood, especially of those who are obliged to spend much of their time in it and who do not exercise in the open air. It becomes exceedingly poisonous if breathed and rebreathed by a large number of persons in close quarters, and the condition produced is known as *ochlesis*, or "crowd poisoning."

The history of the past gives fearful instances of such poisoning, and to a greater or less extent it is still to be found in many tenement and cheap lodging houses, in the holds of some emigrant vessels, in overcrowded schools, churches, and theatres, and especially in cheap places of amusement (*a*). Formerly, overcrowding, with its consequent filth, was the cause of many deaths from jail, ship, or typhus fever; and it is still the prolific source of many subtle diseases, especially in cities and large towns (*b*).

272. Gaseous Matters.—The gases which most often, either alone or in combination with suspended matters, make air impure and dangerous to life are *carbon dioxide*, *carbon monoxide*, *illuminating gas*, *hydrogen sulphide*, and *sewer gas*.

273. Carbon Dioxide, or carbonic acid gas, is the most constant gaseous impurity in the atmosphere. It is a heavy, invisible gas resulting from the combustion of any substance containing carbon, from the decay and putrefaction of any animal or vegetable substance, or from fermentation, and is given off during the respiration of animals. In nature it is diffused throughout the atmosphere, and is absorbed by trees and plants. In them the gas is decomposed, the carbon being retained for their growth, while the oxygen is returned to the atmosphere.

That there is a compensating interchange of oxygen and carbon dioxide between plants and animals is shown in a well-arranged aquarium. The fish give off the necessary amount of carbon dioxide for the health of the plants, and the plants furnish enough oxygen for the fish.

Notwithstanding the diffusive power of gases and the absorption of carbon dioxide by plants, it occasionally accumulates in such quantities as to poison the atmosphere in various places. When the moisture in the atmosphere is in excess, as in foggy weather, the amount of carbon dioxide may increase from about four volumes in ten thousand to eight volumes. In manufacturing districts the accumulation is very great. When generated in low, confined places, such as cellars, beer vats, cesspools, caves, and mines, it may be retained for a considerable time, partly by its weight and partly because it is generated faster than it can be diffused in these places. The air in such places, especially in the lower stratum, is dangerous to breathe and incapable of supporting combustion. In the "Dog's Grotto," near Naples, and in various other places, carbon dioxide is continually generated (*a*). This gas, if in considerable amount, may be detected by the extinction of a lighted candle introduced into the place to be tested.[1]

274. The investigation of the air as to organic impurities is necessarily prolonged and tedious, but the amount of carbon dioxide in the atmosphere is readily ascertained. As these impurities are generally associated with carbon dioxide, the amount of the gas present is a guide to the respiratory impurity of the air.

[1] "Choke damp" is the term given by miners to the carbon dioxide generated in mines.

It is said that the odor of crowd poison becomes generally perceptible when the carbon dioxide in a room exceeds six parts in 10,000 volumes of air. This is the amount mentioned by Dr. Parkes, the eminent sanitarian, as the "limit of permissible impurity," yet a much larger amount is often found in the air of houses, schools, etc. But though the odor of crowd poison be perceptible, carbon dioxide itself has no odor. Usually, therefore, its subtle effects are upon us before any warning has been given. It accumulates in houses not well aired, from illuminating gas, lamps, furnaces, stoves, decaying vegetables and wood, and from our own breathing (*a*). The results of breathing it in any considerable quantity for a length of time are headache, dulness, giddiness, nausea, chilliness, and even unconsciousness and death.

275. Carbon Monoxide, or carbonic oxide, is a much more poisonous gas than carbon dioxide, for it not only robs the air of oxygen, but destroys the blood corpuscles, and its evil effects are not readily dissipated by fresh air, as is the case with carbon dioxide. It is colorless, has but little odor, and when not combined with gases that have odor may slowly insinuate itself into a room and gradually undermine the health of the occupant. It is one of the ingredients of illuminating gas, and also results from imperfect combustion of coal. It sometimes passes through ill-fitting joints in furnaces and stoves, and even through cast iron when it is very hot. This is most likely to happen when the supply of cold air is insufficient, or the escape of the products of combustion is largely prevented by dampers, or by smoke-pipes that are too small. A stove or furnace should therefore be so large that it can warm the room without being itself very

hot. Smoke-pipes should be large, and with perforated dampers. More coal will thus be consumed, but the danger will be lessened.[1] Combined with sulphur compounds in the imperfect combustion of coal, carbonic oxide has the peculiarly disagreeable odor known as that of "stove gas." This gas is irritating to the nostrils and throat, causing dryness, constriction, and a disagreeable taste.

276. Illuminating Gas, as ordinarily delivered to the consumer, is mainly a mixture of marsh gas[2] (about one-third), sulphur, and carbon monoxide. The very best kind of illuminating gas poisons the air into which it may escape; but if the gas has not been thoroughly purified, it contains other and much more poisonous ingredients than those already named. The old, the very young, and all whose sense of smell is not acute, may be gradually poisoned by the slow escape of gas from a leaky gas pipe, without perceiving the odor of the gas.[3]

277. Hydrogen Sulphide, or sulphuretted hydrogen, is a colorless gas, with the odor of putrefying eggs. It is very poisonous. When breathed in a pure state, it quickly proves fatal, destroying the blood corpuscles, and is dan-

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[1] It is much better to regulate the supply of air admitted to stoves and furnaces for draught, than to rely upon dampers. Truly, "it needs a philosopher to run a furnace properly."

[2] It is so called because in hot weather it may be evolved from the putrefaction of vegetable matter in the mud at the bottom of stagnant pools, and is the same as the "fire damp" of the coal mines. It is a compound of carbon and hydrogen, and is colorless, explosive, and poisonous.

[3] To detect leaks in gas pipes, apply soap-suds to the suspected leaky joint. The formation of bubbles will show an escape. This is safer than trying the joint with a lighted match.

gerous even when diluted with atmospheric air.[1] It is a component of sewer gas; and in houses and other buildings it emanates from decomposing refuse in garbage receptacles, from cesspools and drains.

278. Sewer Gas,[2] especially of late years, has been held responsible for much of the sickness in houses connected with drains and sewers. Sewer-gas poisoning, from defective plumbing of houses and insufficient airing of the sewers, undoubtedly exists, but the plumber is frequently blamed for sickness which is due to other causes. Sewer gas may be odorless and escape into a room without its presence being known, or it may have a faint, sickly odor, or an odor like that of sulphuretted hydrogen. In either case it may lower the vitality, thus making us susceptible to disease. Its presence should be excluded by well-ventilated sewers, and drains with tight joints; the pipes, closets, and basins should be so placed that, if a leak occurs, it will not imperil the health of the inmates of the house.[3] Sewers and drains should be thoroughly cleansed and disinfected from time to time.

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[1] One eight-hundredth part in the air is sufficient to kill a mouse.

[2] A compound of carbon dioxide, nitrogen, sulphuretted hydrogen, ammonium sulphide, disease germs, and other substances.

[3] A refrigerator connected with the sewer leads to the tainting of articles kept in it. Pipes which convey water from roofs and connect with the sewer may convey sewer gas into the upper part of the house, if these pipes open under windows, as is sometimes the case with mansard roofs. Occasionally rats gnaw through lead pipes, and thus sewer gas escapes into houses; or the roots of trees penetrate faulty joints of drain pipe. Workmen have lost their lives in the opening of old cesspools, when the contents were stirred, though before that operation a candle would burn if lowered into the vat. During and after heavy rains, swollen rivers and streams often prevent sewage from escaping into them, and sewer gas "backs up" into houses, causing discomfort and sickness.

279. Devitalized Air is a term which is applied to air that has been robbed of much of its life-sustaining property by various means, as by mixture with the emanations from decaying lumber in cellars, from musty clothes stored in closets, from poisonous wall papers (*a*) or decomposing paste between the layers of wall paper, from decomposing food in pantries, or from tobacco smoke (*b*). Houses built upon ground made by filling depressions with dirt and ashes mingled with decaying animal and vegetable matter are sometimes permeated by deleterious gases, which give rise to symptoms of malarial poison among the inmates.[1]

280. It has been shown by Pettenkofer and others that bricks, ordinary mortar, cement, and sandstone are permeable by air and moisture.[2] Moisture also collects upon the walls of new houses or those in damp situations, and is a source of disease (*a*). Newly built houses should not be occupied as dwellings until the mortar, cement, etc., become thoroughly dry. It is also a matter of great importance that the ground upon which houses are built should be thoroughly drained and dry, else the dampness will be apt to cause rheumatism and other severe affec-

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[1] Such land should not be built upon until three years after filling in.

[2] "A remarkable case in a London house has come to my knowledge, which gives a distinct proof of the much greater passage of gas through the walls in winter than in summer. A small room occasionally used was noticed sometimes to have an unbearably bad smell. This was never noticed in summer, nor in winter unless a fire was lighted in the room. The drainage was suspected and examined, but was found perfect; yet here was this extraordinarily foul air making its way into the room whenever the interior was warm and the exterior cold. The cause was a dust bin built against one of the walls, and the filtration of the air through this and the house wall into the room." — HARTLEY, *Air and its Relations to Life.*

tions.[1] Harmful gases may be conveyed, even by the best soil, from leaky drains, sewers, gas pipes, and other sources of impurities. Pettenkofer mentions an instance of death from illuminating gas, which had penetrated through the earth a distance of twenty feet, from a leaky pipe, into a basement.

281. Country and City Air.—Cowper says, "God made the country, and man made the town." Undoubtedly the air is very pure in those country districts where the inhabitants are not crowded together; where there are no factories or nuisances, no decomposing garbage or other refuse; where the water supply is abundant, and no stagnant water exists; where the houses are well drained, and so placed that the sunlight enters the rooms; and where the dwellings and out-houses are at least one hundred feet apart. But where these conditions do not exist, the better portions of most towns and cities are preferable. Moreover, in the country there are not so apt to be health boards and sanitary associations to remedy evils.[2]

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[1] Sand absorbs and retains but little water; clay, ten to twenty times as much as sand; while rich earth absorbs and retains, it is said, forty or fifty times as much. Hard, rocky soils allow but little water to pass through them. An ideal building site is upon the side of a gently sloping hill (with a rocky and sandy soil), looking toward the south, not near a marsh or sluggish stream, with good drinking water, and enough trees to protect it from the strong sunlight and to absorb any excess of moisture there may be in the soil. On the other hand, very many trees, by affording too much shade, make the surroundings of a house damp and assist in the production of malaria. It is of importance that the trees should be of such kinds as to afford ample shade, and at the same time have no unpleasant odor. The trees which best meet these requirements, and are most pleasing to the eye, are the oak, elm, maple, tulip tree, ash, mulberry, linden, horse-chestnut, and walnut.

[2] By the enlightened and active work of such bodies much good has been done. By proper drainage of low, swampy, or submerged lands,

On the other hand, the numerous overcrowded and dirty tenement houses in the large cities are productive of very great mortality,[1] and are often sources of danger to the better portions, being the starting-points of infectious diseases and low forms of fever (*a*). Of late years model tenement houses have been erected in some of our cities, in which overcrowding and uncleanliness are prohibited by the owners (*b*).

282. Fresh Air.—*The importance of an abundance of fresh and pure air* will be appreciated when we consider that wild animals kept in confinement frequently die from diseases due to confined air or an insufficient amount of air (*a*). As Dr. Richardson puts it, "Open air is a powerful disinfectant, protecting the gypsy from germs which we vainly fight with all the aid of science." Some of the impurities in the air act harmfully by lessening the amount of oxygen, some irritate the air passages and lungs, and others poison the blood directly by being absorbed by the air-cells. The general effect of most of the impurities is to produce pallor, headache, drowsiness, loss of appetite and strength:

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malarial fevers have been crowded out, and the soil redeemed for cultivation or for building purposes. The health tracts and reports published by such organizations contain much valuable information.

[1] The density of population in the tenement districts of large cities is not generally understood. In one of the largest cities in this country the police census of 1895 reports one block, size 375 × 200 feet, with a population of 2628, rate per acre 1526; another block, size 200 × 300 feet, population 2244, rate per acre 1774; and many districts containing 400, 500, and 600 persons per acre. In Bethnal Green, London, there are 365.3 people per acre; in Whitechapel, 303.5. In Bombay, where there is an average of 57.7 persons per acre, there are three districts in which there are 680, 715, and 750. It will be difficult for any person living in the genuine country to imagine so large a population per acre as these mentioned.

They undermine the health, and so increase the susceptibility to organic and infectious diseases. If the impurities are in large amount, vomiting, marked prostration, and even death may result.[1]

283. Purification of Air. — *Ventilation.* Many of the dangers arising from impure air may be obviated by suitable ventilation, purification by means of chemicals, by heat, or by steam.

By *suitable ventilation* is meant the free admixture of out-door air with that of buildings and apartments, but so modified as to temperature and velocity of current, in its admission into rooms, that draughts are prevented. Suitable ventilation should take place by night as well as by day. The airing of one room by introducing the confined air from another is not suitable ventilation; neither is it right to exclude from our sleeping rooms the night air, of which so many live in fear. In fact, night air generally contains less carbon dioxide than day air.[2] But draughts of cold air, either by night or by day, are injurious to all, especially to the feeble, the very young, and

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[1] What will poison one person may have but little effect upon another less susceptible. There are some people who seem to catch everything, while others can expose themselves to impure air and sustain no apparent injury. In cities, noxious gases from factories sometimes poison susceptible people, and remain for some time undetected.

Living in a pure atmosphere, good food, suitable exercise, sufficient warmth, and agreeable surroundings have a marvellously good effect upon feeble and many sick persons. Homes for consumptives have been established in Europe and in some of our states, where these sanitary measures can be carried out. The United States Government has established a similar resort at the far West for consumptive soldiers.

[2] Thousands of soldiers, hunters, and lumbermen sleep every night in tents, open sheds, and even in the open air, without injurious consequences.

the aged. They lower the temperature of the body, and induce internal congestions. "A cold draught of air cuts like a knife."[1]

284. In buildings having furnaces or stoves connected through their air-chambers with the out-door air by means of air-boxes or flues, the air that enters in cold weather is warmed and its velocity somewhat diminished by contact with the heated iron of the furnaces or stoves. All furnaces should have roomy air-boxes, covered at their inlet with cheese-cloth, to catch dust.[2] If possible, the air should be drawn from above the street level, in order to be comparatively free from dust and other suspended matters.

Cold air may likewise be better adapted to our use by its passage through one or more layers of fine wire gauze, woollen, cotton, or linen cloth fitted in frames into the windows, or arranged as screens before the open windows. In very warm weather the air may be made more comfortable by suspending dampened cloths in the rooms.

285. Ventilators are appliances for the free passage of air into and out of ships, mines, dwellings, etc. They differ very much in structure and mode of action. In large ships (such as war-vessels) and in great mines, the fresh air is sucked in and the foul air forced out by engines. In dwellings, in very cold weather and when the wind is blowing hard, sufficient out-door air for ventilating purposes may be sucked in through the air-flues

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[1] "If cold wind reach you through a hole,
Go make your will and mind your soul." — *Old proverb.*

[2] It is shameful to have to state that, at the present day, houses are sometimes built without air-boxes, or with boxes that open into cellars instead of out of doors. Occasionally foul air is sucked into apartments from cellars, through defective air-boxes, causing much sickness.

of furnaces, or by the sides of window sashes. A current is created by the impure air escaping through open fireplaces and chimneys, especially when fires are burning in the grates, stoves, and furnaces.[1]

286. Ordinarily it is necessary to obtain air in larger quantities (*a*). This may be effected through cotton cloth, etc., as before described, through revolving metal wheels inserted into window-panes, through small diagonal openings in the window-sashes, or by placing under the lower window-sash a board, occupying the whole width of the sash, and from three to six or more inches high.[2] The air thus passing in is not deflected directly downward upon the occupants of the room. In factories, institutions, schools, vehicles, and similar places where ventilation is to be provided for many persons, it should be automatic; for if regulated by the varied judgment of the numerous inmates, it will prove ineffective (*b*).

287. The Amount of Fresh Air needed for Each Person in a Room.—Estimates of the necessary amount of air and

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[1] Fireplaces should not be entirely closed; neither is it well to have them so large and open that a great draught is created, thereby drawing the air too strongly out of the room and too much heat up the chimney. Such fireplaces must needs consume a large quantity of fuel in order to radiate sufficient heat to be equally diffused throughout the room. Stoves with outer jackets or envelopes, which receive and warm cold air as it passes through them into rooms, are preferable to ordinary stoves, which throw out dry and superheated air.

[2] A simple and effectual arrangement is that of Dr. Keen, viz., fastening "with tacks or loops a piece of paper or cloth across the lower ten or twelve inches of the window-frame, and then raising the lower sash more or less, according to the weather." It will probably occur to the reader that the cloth so placed may be suitably ornamented on one or both sides.

cubic space which each inmate of a room requires, under varying circumstances, have been made by sanitarians as guides to proper ventilation, — since the detection by smell of harmful odors or a sense of closeness is not always certain.[1]

When the amount of carbon dioxide in the air of an occupied room is beyond six parts in ten thousand, the air becomes oppressive and dangerous, not only on account of the carbon dioxide present, but also on account of the poisonous organic matter exhaled by the lungs. The air is also vitiated by gas jets and lamp flames.[2] To maintain air sufficiently pure for respiratory purposes in a room, at least 3000 cubic feet of fresh air must be introduced every hour for each individual. For each adult,[3] at least 600 cubic feet of air space are needed in an ordinary room to insure the requisite change of air without draughts, since the air should be completely changed three or four times an hour (*a*).

288. Disinfection. — Any substance that will destroy the infecting power of infectious material is a *disinfectant*. An agent which destroys bad odors is a *deodorant*, or *deodorizer*. An agent which arrests putrefactive decomposition is an *antiseptic*. An abundance of fresh air not

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[1] Especially by persons who are mouth breathers, who have nasal catarrh, or whose sense of smell is blunted by living in a close and polluted atmosphere.

[2] According to Pettenkofer, a burner consuming five feet of gas per hour gives off as much heat as eight men, more carbon dioxide than three men, and as much watery vapor as five men. One of the claims made for electric lights is that they give out very little heat and carbon dioxide.

[3] It is claimed by some sanitarians that there should be no distinction between adults and children, as to the necessary amount of air space.

only dispels disagreeable odors, but frequently acts as a disinfectant by virtue of its oxygen.[1] Smouldering paper, burning coffee, cologne water, and other things commonly used as purifiers act only as deodorants, simply replacing one odor with another that is stronger. They have absolutely no value as disinfectants.

Charcoal, dry loam, and ashes are valuable deodorants to use in out-houses and cesspools. The material so deodorized, when exposed to the sun, air, and light (as it should be, at a considerable distance from dwellings), will be disinfected by these agencies. Slaked lime, added to the compost heap, will hasten the antiseptic and disinfectant processes begun by the sun, light, and air. The coating of walls, especially cellar-walls, with lime-wash is a useful method of sweetening the atmosphere, and should be frequently repeated. Cold arrests putrefaction, but does not destroy germs; whereas steam under pressure (221° F.) for ten minutes, or boiling water for half an hour, will do so. Certain chemicals, such as chloride of lime and mercuric chloride, in a strong solution, will destroy germs. In a weak solution they prevent putrefaction (*a*).

289. Sunlight.—In addition to an abundance of air of the right kind, animals need sunlight. Without this the blood is impoverished and vital energy is diminished (*a*). Secluded from the light, human beings become pale and sickly, just as plants do in cellars; and, like plants, they grow stronger and healthier on removal into the light.

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[1] Rigorous cleanliness, sunlight, and an abundance of fresh air will not only keep away the visible and obnoxious filth, but will lessen the virulence of typhoid fever, cholera, and other infectious diseases which are sometimes classed as filth diseases.

Bacteria thrive best in darkness and in moist places.[1] Most of them are killed by strong sunlight (*b*).

During the prevalence of epidemics in some of our southern cities, it has been noticed that there is more sickness on the shady than on the sunny side of the streets. Houses should be so constructed that the sun can shine into every room during some part of each day. But just as we have found to be the case with the other vital requisites of man, so there may be an *excess of light*, and of its accompanying heat. Too great exposure, in warm weather, to the direct rays of the sun may induce sunstroke. Even in the frigid zone the glare of the light on the snowy landscape is attended with danger to the sight, — a danger which is also incurred by those who have the sun's rays reflected upon them from white sand and other reflecting objects.[2]

QUESTIONS.

1. Of what service to man is the pressure of the atmosphere?
2. What is the ordinary composition of air?
3. What is said of the relative proportions and uses of nitrogen and oxygen?
4. Of what use are the other ingredients of the air?
5. Of what does the dust in the air consist, and from what sources does it come?
6. How should we protect ourselves from its evil effects?
7. What is to be said of "disease germs" and of their development?

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[1] The virulence of most disease germs is preserved in dust, but the bacteria of cholera die when dry.

[2] "To obviate the dangers of an excess of light, nature carpets the earth with *green*, and either vaults the heavens with *blue*, or draws over them her *gray* curtain of cloud, and at proper intervals spreads over us the *black* pall of night, bringing with it refreshment and rest."

8. What of the organic nitrogenous matters thrown off by the lungs?
9. To what is the term *malaria* applied, and what are some of the causes of malaria?
10. What gases corrupt the atmosphere, and which one is constantly present therein?
11. Whence does the atmosphere derive its carbon dioxide, and why should so poisonous a gas be an *essential* ingredient of the atmosphere?
12. When and where is it apt to be in excess, and what are the effects?
13. What is to be said of carbon monoxide? of illuminating gas? of sulphuretted hydrogen? of sewer gas?
14. What other emanations than the above gases *devitalize* the air?
15. What is to be said of damp building sites and of leaky drains and gas pipes?
16. State the relative advantages of city and country life.
17. What are the effects of an impure atmosphere upon the health, and how may they be obviated? Illustrate as to ventilation; as to the use of chemicals.
18. What effects follow a deprivation of light? What its excess?

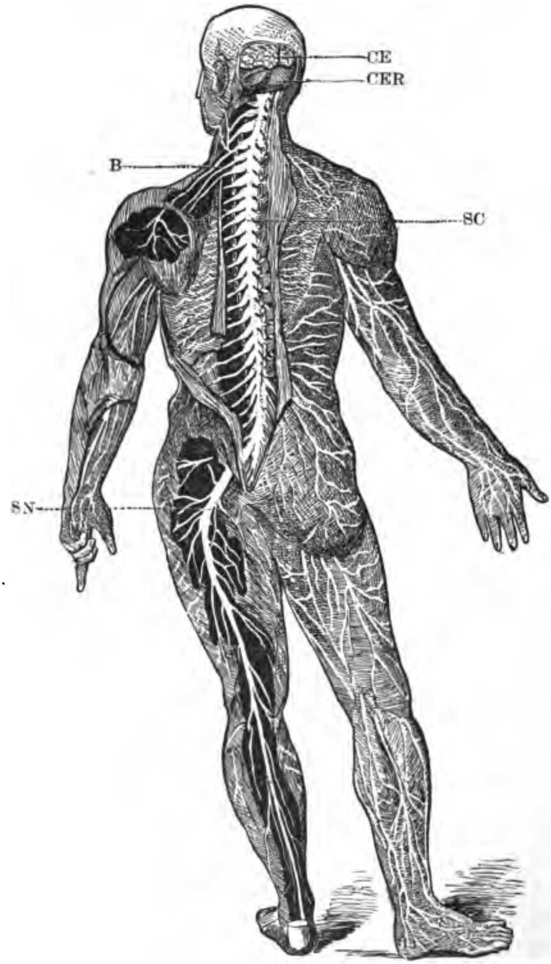

Fig. 86.

Posterior view of the spinal cord, a portion of the cerebrum and cerebellum, and some of the nerves of the cerebro-spinal system. On the left side of the body some of the tissues are removed to show the deeper nerves, while the right side shows certain superficial ones.

CE, cerebrum. **B, nerves distributed to the arm.** **SN, sciatic nerve.**
CER, cerebellum. **SC, spinal cord.**

CHAPTER XV.

THE NERVOUS SYSTEM.

290. Predominance of Nervous Processes in Man.— Some of the processes already studied, viz., digestion, circulation, absorption, and respiration, are common to both animals and vegetables; but the processes by which consciousness, will power, voluntary motion, sight, hearing, etc., are accomplished are, so far as is known at present, peculiar to animals. One animal is superior to another in proportion to the number and development of these functions. In man their number is the greatest and their development the highest, so that man maintains supremacy over all other forms of creation.

291. Use of the Nervous System. — In health, all the organs of the human body possess a peculiar property known as *irritability*,[1] which enables each one to perform its function at the right time, in the right way, and in accord with the functions of other organs. Thus the gastric juice is secreted whenever any substance is introduced into the stomach, and the number of the pulsations of the heart bears a definite relation to the frequency of the respiratory movements. This irritability, or normal

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[1] "Irritability (*irrito*, I provoke). In physiology, this word signifies the power of responding to a stimulus, as exemplified by the contractility of muscular tissue. In medicine, irritability implies an undue excitability of an organ or tissue, from disease or disorder, such as of the brain, spinal cord, stomach, eye, or bladder." — QUAIN, *Dictionary of Medicine.*

excitability, of tissues, together with the performance of all vital functions, is made possible by the *nervous system*, through which all impressions are received, and by means of which motion, sensation, thought, etc., are produced. This system regulates all the movements of the body, both voluntary and involuntary, and all the processes, and harmonizes the functions of the various organs.

292. Everywhere in the healthy body there is coöperation for the common good. Were it not so, man would be a collection of disorderly organs, each one trying to live to itself, and to act for itself. The heart varies its rapidity of action to keep pace with the muscular activity of the individual. The muscles work together to produce varied movements of the body.

The various organs of the body are connected with the brain — the centre of operations — by means of nerves, which are like so many electric wires running to and from the seat of government of the community. By this arrangement, notice of any disturbance is immediately communicated to headquarters, so that a remedy may be promptly furnished. The importance of the nervous system, with its harmonizing influence, is obvious when we witness the results of disturbances therein, such as irregular action of the muscles of the extremities in spasms and cramps, fluttering of the heart, or convulsions.

293. General Arrangement of the Nervous System. — Owing to the difference in location and function of its various parts, there are two divisions of the nervous system; viz., the *cerebro-spinal nervous system*, and the *sympathetic*[1]

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[1] At one time it was believed that one part of the body became diseased through sympathy with another part. As the second of the

nervous system. The first-named division includes all that portion of the nervous system contained within the cranial cavity and the spinal canal; viz., the brain and the spinal cord, together with the nerves which branch off from each. This system presides over the functions of animal life, as volition, sensation, etc.

The second-named division includes all that portion of the nervous system located principally in the thoracic, abdominal, and pelvic cavities, and distributed to the internal organs. Its special function is the regulation of involuntary processes, like growth and nutrition. It is connected with the cerebro-spinal system.

294. Nervous Tissue. — *Nerve fibres and cells.* The nervous system, whether simple in arrangement, as in the starfish, or more complicated, as in the higher animals, consists of two different kinds of tissue, the one white and the other gray. These differ from each other not only in color, but in structure and mode of action.

The *white matter* constitutes the bulk of the nervous tissue, and is in large quantity on the exterior of the spinal cord and in the interior of the brain. To the unaided eye, it seems to be a homogeneous mass of white, semi-solid material. In reality it consists of slender threads, called *nerve fibres*,[1] which for the most part lie parallel to one another, and are kept in place by delicate connective tissue. Nerve fibres, united in bundles large

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above-named divisions of the nervous system is largely responsible for the spread of disorder and disease, it has been called sympathetic, in deference to the old belief. It is also sometimes called *ganglionic*, owing to the fact that it is largely composed of ganglia, or masses of gray nervous matter.

[1] They vary in breadth from $\frac{1}{2000}$ of an inch in nerves, to $\frac{1}{10000}$ of an inch in the brain.

enough to be seen with the naked eye, form *nerves*. *The sole function of nerves and nerve fibres is to convey nervous impulses.*

295. The *gray matter* of the nervous system is of an ashen-gray color, and constitutes the *cortex* — the external or convoluted layer of the brain — and various deposits in the substance of that organ. It also forms the centre of the spinal cord, and the masses of varying size, called *ganglia*,[1] which are connected with certain nerves and are especially numerous in the sympathetic system.

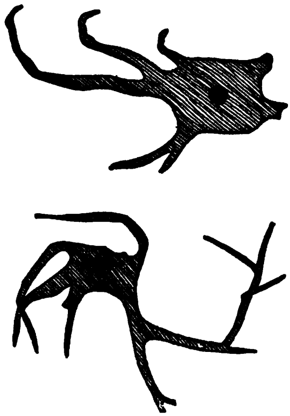

Fig. 87. (GRAY.)
Nerve Cells from Spinal Cord. (Magnified.)

Under the microscope, the gray matter is seen to consist mainly of cells of peculiar shape, called *nerve cells*, intermingled with connective tissue and very small nerve fibres, the smallest of which are *nerve filaments*. These cells vary in form and size.[2] Each one consists of granular material containing a large nucleus and a nucleolus, and has several branches or processes, one of which connects with the axis cylinder — the central conveying portion of a nerve fibre[3] (*a*).

Each collection of gray matter, consisting, as it does,

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[1] From the Greek *γάγγλιον*, "a knot."

[2] Viz., from $\frac{1}{4000}$ to $\frac{1}{50}$ of an inch in diameter. The cells in ganglia are known as "ganglionic cells." The term is sometimes used to include all nerve cells.

[3] The connecting process of the cell is sometimes called the *neuron*.

of groups of nerve cells, is a *nerve centre.* Its function *is to receive nervous impressions, to originate and impart nervous force or impulses, and also to transmit them from one nerve cell to another.*[1]

296. Nerves are bundles of nerve fibres, between which is connective tissue for support and as a framework for capillaries and lymphatics which nourish the parts and carry away wastes. Each fibre is distinct and may act independently of every other. Most fibres are, in fact, insulated by connective tissue and fatty matter, as are the wires of a cable by rubber.[2]

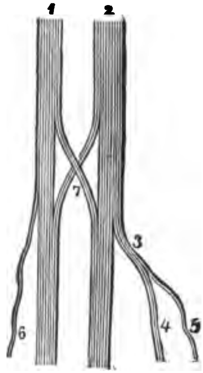

Fig. 88. (LEIDY.)

Mode of Branching of Nerves.

1, 2, two bundles of nerve fibres.
3, a branch of three fibres.
4, branch of two fibres.
5, 6, branches of single fibres.
7, decussation between two nerves.

The nerves connected with the brain and spinal cord are divided, as to function, into *sensory*, or *afferent*, which convey sensory impressions or impulses *to* these nerve centres, and *motor*, or *efferent*, which convey motor impulses *from* these nerve centres.

The largest nerves, or those near

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[1] A nerve centre may be likened to a switchboard of a telephone exchange (which might be called a telephone centre), receiving messages from one quarter, originating and sending out messages to another, or transmitting a message received from one place to another. In a telephone exchange the message is transmitted by connecting the wire from the sender with the wire to the receiver. In the body the message probably leaps from one nerve cell to another, as these cells in a nerve centre are not all connected with one another.

[2] If this insulating material disappears or softens to such an extent as to allow the conducting portion of adjoining fibres to touch, nervous impulses will be sent to portions of the body for which they were not intended, just as telephone messages go astray if wires are crossed.

the nerve centres, are composed of both afferent and efferent fibres, and are known as *nerve trunks.* As they go to the tissues, these trunks separate into smaller nerves (consisting of either afferent or efferent fibres, as the case may be), and these into still smaller ones, and finally they end in or among the cells of the body as nerve filaments so small that they cannot be seen except with a microscope.[1]

When nerves branch, or decussate (*i.e.* cross each other), some of the fibres of which they are composed leave the nerves, and branch off.[2]

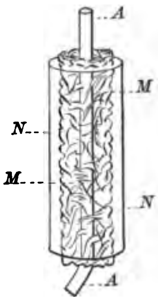

Fig. 89.
Diagram of Structure of Medullated Nerve-fibre.
N, neurilemma.
M, medullary sheath.
A, axis cylinder.

297. Structure of Nerve Fibres.—Nerve fibres are of two kinds, *medullated* and *non-medullated.* Each has in its centre, from end to end, a delicate core, the axis cylinder, which connects with a nerve cell, and is the essential or conducting portion of the fibre. Covering this core, in medullated fibres, is a sheath of white fatty material, the *medullary sheath* (having nuclei in its course), and outside of this is a thin, delicate covering of connective tissue, the *neurilemma*, or primitive sheath. These sheaths are frequently absent in nerve filaments.

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[1] The *sciatic* nerve, located in the back part of the thigh, is a very large nerve, as large round as the tip of the little finger. The painful affection sciatica results from an irritation or inflammation of this nerve.

[2] Nerves distributed to the walls of blood-vessels are *vaso-motor* nerves; those which stimulate gland cells to action are *secretory* nerves; those which check the action of certain organs are *inhibitory.* The nerve fibres which connect the brain and spinal cord with distant organs are called *peripheral* nerve fibres, to distinguish them from those within the brain and spinal cord. The end of a nerve or nerve fibre nearest its nerve centre is the inner, or *proximal*, end; the other is the *distal*, or *peripheral*, end.

The non-medullated fibres, sometimes called gray fibres, have no medullary sheath, only the axis cylinder and the neurilemma. These fibres are found mainly in the sympathetic system. The medullated fibres are found in the brain, spinal cord, and in large nerves.

298. **Interdependence of Nerve Fibres and Cells.** — A nerve fibre, connected by its axis cylinder with a nerve cell, is in reality an elongated process of the cell. Taken together, the cell and its fibre may be considered an anatomical unit. Each depends upon the other. A nerve fibre severed from the cell it is connected with degenerates and is no longer capable of conveying any message. The muscle or other part of the body to which it goes, or from which it comes, also degenerates and cannot do its work. The cell, deprived of needed nerve stimulus, grows feeble from inactivity.[1]

299. **Nervous Impulse**, or nerve force, the peculiar power transmitted by the nerves, is believed to be of a molecular nature, and in the form of a wave.[2] Its velocity is so rapid (usually 100 feet per second) that its transmission seems to be instantaneous.[3] Nervous impulses are put in

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[1] Some physiologists state that if a fibre dies as the result of an injury, its connecting cell can produce a new fibre growing out from the cell body.

[2] The ancients, believing nerve force to be a fluid, called it the nervous fluid. It was once supposed to be of an electric nature; but electricity travels 1000 miles per second, and the nerve current never more than 200 feet.

[3] An act of volition is said to require $\frac{1}{28}$ of a second; a simple distinction or recognition of an impression, $\frac{1}{25}$ of a second.

"In the case of the ear, when the sound attended to is that of two electrical sparks quickly succeeding each other, it can be perceived that there are two, and that one is earlier than the other, when it precedes it by no more than 0.002 sec." — POWERS, *Physiology*.

motion by stimuli, either from within or from without the body, such as food, waves of light and sound, the emotions, the application of electricity or other agents. These impulses, when aroused, produce the various motions, sensations, and functions incident to the body. Normally they rarely, if ever, originate in the course of nerve fibres, but are produced either at the outer ends of fibres in special structures like the sense organs, or at their inner endings in nerve cells. On the other hand, artificial stimulation, such as electricity applied in the course of a fibre, will produce impulses, just as an electric wire can be tapped. Heat increases the conductive power of nerves, and cold diminishes it.

300. Nerves kept in action (*i.e.* strained, or put on the stretch) for a considerable time, as in the repeated contraction of the same group of muscles, become fatigued and need rest. The nerve fibres, their connecting cells, and their capillary blood-vessels become weakened by such abuse, and accumulate carbon dioxide and other wastes. Pitiful examples of fatigued and poisoned nerves and muscles are seen in some of the competitors in long-continued walking and bicycle contests.

301. The Brain and Spinal Cord; their Relation and Membranes. — The *brain* is the great mass of nerve tissue which occupies the cranial cavity, and is continuous (through a large opening in the base of the skull) with the spinal cord.[1] Both are divided by a longitudinal furrow into two portions, right and left.

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[1] The spinal cord is sometimes considered as a part of the brain, the two constituting the great cerebro-spinal centre.

The brain and the spinal cord are protected from various injuries by their strong, bony encasements, and from friction against these walls by three coverings, or membranes, by connective tissue, and by fluid between two of the coverings. The outermost membrane, the *dura mater*,[1] is fibrous and strong. It lines the cranial cavity and spinal canal, and has various shelf-like expansions in the former for the support of different portions of the brain. The innermost membrane, the *pia mater*,[2] — in reality a fine network of capillaries in the meshes of a delicate connective tissue, — is in close contact with the brain and spinal cord, dipping down into their furrows. Between the dura mater and pia mater is a delicate sac-like membrane, the *arachnoid*,[3] containing a fluid known as the cerebro-spinal fluid. The protection and freedom of motion afforded by this sac, with its soft and yielding liquid contents, are evident.

302. Divisions of the Brain. — The brain consists of three masses, or divisions:[4] first, the *cerebrum*, or brain proper, which is the largest, and occupies nearly the upper two-thirds of the cranial cavity; next, the *cerebellum*, or little brain, which about fills the lower and back portion of the cavity; and third, the *medulla oblongata*.[5] This last is

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1 "'Hard mother'; called *dura* because of its great resistance, and *mater* because it was believed to give rise to every membrane of the body." — DUNGLISON, *Medical Dictionary*.

2 "Delicate mother."

3 A name originally applied to delicate membranes resembling spiders' webs. The term *arachnoid* is from a Greek word, meaning "spider."

4 These are sometimes spoken of as the *fore-brain*, *mid-brain*, and *hind-brain*.

5 *I.e.* "oblong pith" or "marrow." It is sometimes called the bulb, oblong cord, or spinal bulb.

the smallest part, and is the broadened commencement of the spinal cord (Fig. 90). These three parts of the brain

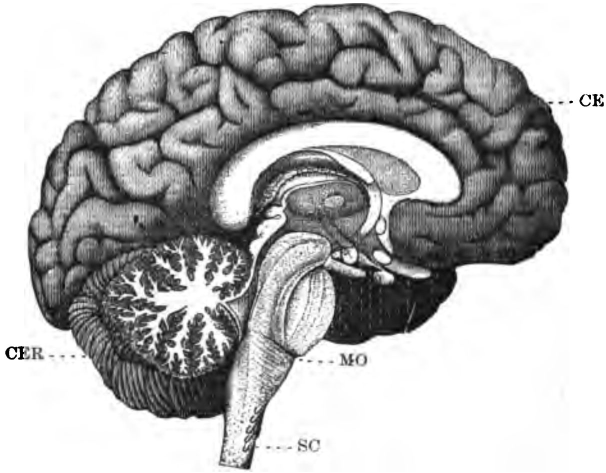

Fig. 90.
Vertical Section of Brain.

CE, cerebrum, left hemisphere.
CER, cerebellum, left portion.
MO, medulla oblongata.
SC, spinal cord.

are connected with one another, and all contain both white and gray matter.

303. **The Size and Weight of the Brain** depend somewhat on the size of the individual, but they also bear considerable relation to his intellectual capacity (*a*). In the lower animals the cerebellum and the ganglia at the base of the brain are the largest; but in the higher animals the cerebrum, as a rule, increases in size in proportion to the degree of intelligence. In man the size is very much greater in proportion to that of the entire body than in any of the lower animals. The quality of the brain material is also undoubtedly a matter of importance, for

the brains of some very intelligent persons have been found to be comparatively small.

304. The Cerebrum is rounded upon its upper and lateral surfaces, where its shape conforms to that of the skull, while its base or lower surface is more flattened, and rests in front upon the floor of the cranial cavity, and at the back upon a membranous expansion of the dura mater, which separates it from the cerebellum. The longitudinal fissure before referred to divides the cerebrum into two nearly equal parts, called *hemispheres*. These, however, are connected toward their lower portions by a transverse band of nerve fibres called a *commissure*,[1] and also by two columns of fibres[2] which extend upward from the bulb, diverging as they enter the hemispheres.

305. Each hemisphere is everywhere marked, on its outer surface, or cortex, with irregular grooves and ridges, and is covered by gray matter. The undulations thus formed are termed *convolutions*. This convoluted arrangement provides, in a small space, a large amount of gray matter, the source of nervous power. The convolutions, in proportion to their number and well-marked character, indicate the degree of intelligence in animals and man. In young children, especially before the age of seven years, when the brain is very soft and imperfectly developed, and the mental powers are not strong, the convolutions are not well marked. Such is also the case in the lower animals and in the uncivilized races of mankind.[3]

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[1] *I.e.* "point of union of two parts." [2] These are the *crura cerebri*.

[3] "There are exceptions, however, as in the whale and elephant, in which the convolutions are exceedingly intricate and beautiful. The particular arrangement of the fissures and convolutions differs as the brain ascends through the half apes, the apes, and man."

The white matter of the hemispheres is large in amount, and consists of nerve fibres prolonged from various tissues and organs of the body. These fibres terminate in the gray matter of the convolutions and in the ganglia of the brain.[1]

306. The cerebrum is a *single organ*, as far as the intellect is concerned, but a *double one* with relation to the two sides of the body. Impressions from either side of the body are appreciated through the hemisphere on the opposite side, owing to the crossing, in the course of the spinal cord, of nerve filaments which convey sensations. So, too, the bursting of one or more blood-vessels (*i.e.* apoplexy) or the stoppage of a blood-vessel by a clot, on one side of the cerebrum, injures the nervous tissue and produces complete or partial paralysis upon the opposite side of the body, owing to the crossing in the medulla oblongata of nerve filaments that convey motor impulses.

307. Functions of the Cerebrum. — The cerebrum is the *organ of the mind.* It enables one to know, think, originate, and act. It is connected, directly or indirectly, with all parts of the body, and acts as a superintendent. It is that part of the nervous system through which the intellectual and moral powers, or faculties, act.[2] These faculties,

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[1] In the cerebrum are many curious and interesting anatomical arrangements, — cavities, ventricles or water beds, passageways, and curtains, — which, though important to the anatomist and physician, are too intricate and complex to be described here.

[2] Facts in regard to the functions of the nervous system are ascertained from the study of the lower animals, and by experiments made upon them, and also by studying the results of disease and injury in the human being. It is a curious fact that the cerebral substance is not sensitive, but can be

rightly used, make man the "noblest work of God"; for his is the highest organism, and the one which best adapts itself to its environments (*a*).

308. The principal faculties are *memory*, *reason*, and *judgment*. A good memory is essential to healthy development of the intellect. It not only retains facts, but produces them, when wanted, with their connections and relations [1] (*a*). Reason enables us to appreciate the true relation between cause and effect. Judgment requires both memory and reason, and is that faculty by which appropriate means are adapted for the accomplishment of a particular end.

The vigor of the intellect depends more upon the quality than the quantity of the cerebral tissue. The quality is improved by proper use of the mental faculties. It is inferior in those who do not strengthen the memory and the power to reason correctly and to judge aright.

309. Brain Localization. — The attempts made from time to time to locate accurately in the cerebrum the centres of the various mental faculties have not been fully successful. This is probably due to the fact that these

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cut or torn without pain. In general, loss of cerebral substance by disease or severe injury causes impaired memory, tardy, inaccurate, and feeble connection of ideas, irritability of temper, and easily excited emotional manifestations.

[1] "We are apt to be carried away by a vague notion that there is no limit to acquirement, except our defect of application or some other curable weakness of our own. There are, however, very manifest limits. We are all blockheads in something; some of us fail in mechanical aptitude, some in music, some in languages, some in science; memory in one of these lines of incapacity is a rope of sand; there must be in each case a deficiency of cerebral substance for that class of connections." — BAIN, *Mind and Body*.

faculties are of a complex nature, and are produced by a coalition of a number of impressions.

The functions of the rounded masses near the base of the cerebrum, called *basal ganglia*, are not settled, owing to experimental difficulties. But the centres or areas of motion, sight, smell, and hearing are quite clearly localized.[1] The motor areas, or those which are associated with definite motions of the voluntary muscles, are in the upper and side portions of the cerebral cortex, and usually on the opposite side of the body from the muscles moved.

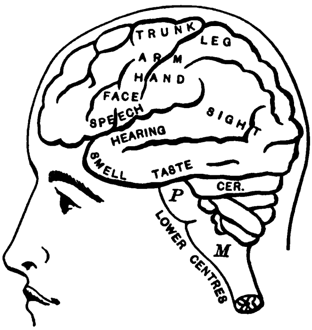

Fig. 91.

Brain Localization.

P, pons. M, medulla. CER, cerebellum.

The surgeon, by the removal of tumors or clots of blood from certain motor areas, has relieved cases of epilepsy and paralysis. Studies of diseased conditions of the brain indicate "that the removal of certain portions of the brain, respectively, or injury to them, will produce blindness, deafness, or lack of smell, etc., as the case may be." The

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[1] Investigations seem to show that the centres for motion, sensation, and the mental faculties are not so isolated as has been hitherto supposed, but that they are more diffused and shade off into each other. Thus a wonderful provision is made for emergencies. If the very heart of a centre or area be injured, there will be oftentimes sufficient nervous tissue remaining to perform the work in a more or less perfect manner.

"The faculty of articulate language appears to reside in the third or inferior frontal convolution of the left side, which convolution would contain both the centre for the memory of words, and the centre for the co-ordination or combination of the movements of speech." — Cooke, *Tablets of Physiology.*

centres for sight are in the occipital lobes of the cerebrum; the centres for hearing, near and behind each ear; for smell, on the sides of the cerebrum in front of the ear.

310. The Cerebellum; its Functions. — The cerebellum has no convolutions. Its surface, or cortex, is of gray matter, arranged in nearly parallel ridges of irregular depth.[1] Its two lobes are connected by nerve fibres, which pass from side to side across the upper and front part of the medulla oblongata. This is called the *pons*, from its resemblance to a bridge.[2]

Like the cerebrum, the cerebellum is without feeling. Its function is the *coördination*, or harmonious regulation, of the movements of the voluntary muscles. The necessity of its directing power is made manifest whenever that power is interfered with, as is shown in the unsteady gait of the drunkard, or in cases of injury or disease of the cerebellum.

311. The Medulla Oblongata. — The medulla resembles the spinal cord in the arrangement of the white and gray matter. Through it run nerve fibres on their way to and from the upper portions of the brain, those that convey motor impulses crossing within the medulla. Fibres also enter it from the cerebellum. From its interior and from the under surface of the cerebrum rise what are known as the *cranial nerves*. These emerge from the cranial cavity through openings in the base of the skull, and are distributed to various parts of the head and neck, to the organs of special sense, and to some of the thoracic

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[1] From the peculiar branching appearance of the gray matter in a perpendicular section of the cerebellum, it is called *arbor vitae*, or tree of life.

[2] Also *pons Varolii*, after its discoverer, Varolius.

and abdominal organs. A still more essential feature of the medulla oblongata is the possession of nerve centres that control respiration, the pulsations of the heart, and the size of the small arteries.[1]

The mental faculties may become almost useless, and sensation and the power of voluntary motion may be lost, by disease or injury of the cerebrum or cerebellum; but life itself remains if the respiratory and heart centres (vital knots, or points, as they are sometimes called) are intact. If these centres are injured, breathing is impaired; if destroyed, death necessarily results. Hence, nature has provided protection for the medulla, by burying it so deeply within the skull that it is seldom injured by blows or falls. Sometimes, however, in fracture of the spinal column near its articulation with the skull, particles of bone are driven into the medulla oblongata, causing instant death.[2] Apoplexy in this part of the brain is also of rare occurrence.

"To the centres of the medulla come impulses from all parts of the body, which may never give rise to conscious sensation, but which so stimulate these centres as to keep them alert (like watch-dogs) to the needs of the organism. Ordinarily, whether asleep or awake, these centres pursue the even tenor of their way. Under some great emotion, when all the energy of our being is centred on one thought

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[1] Other portions of the medulla are said to regulate mastication, swallowing, vocal utterance, and the secretion of saliva and sweat.

[2] Instantaneous death may result from injury to the medulla oblongata without the neck's being broken, as when the atlas is dislocated by the striking of the head upon the bed of a stream in diving from a height into shallow water — a proceeding always attended with danger. Occasionally animals fall dead from sudden injury to the vital point. For instance, a clumsy shanghai rooster, in full pursuit of another, fell over a wooden pail, striking the back of his head, and died instantly.

or supreme effort, these centres may stand in abeyance, or the pang may be so great as to break the vital chain. Higher life is only possible by freedom from the necessity of watching over these functions."

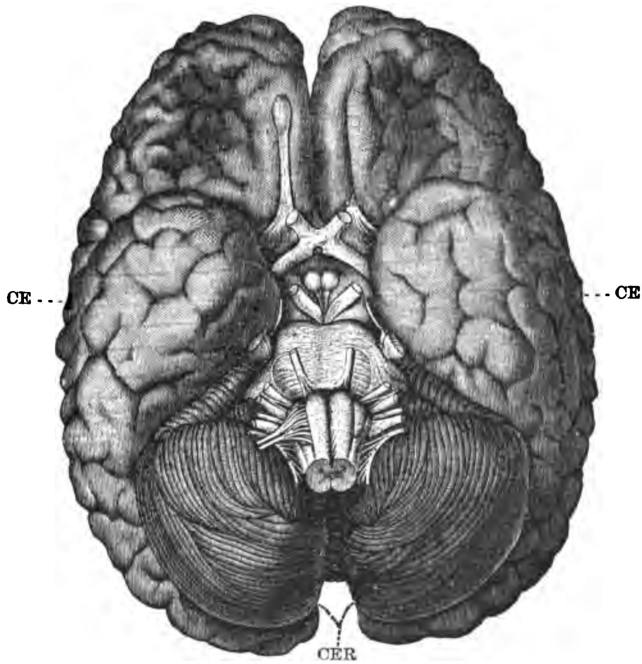

Fig. 92.

The Lower Surface or Base of the Brain.

CE, cerebrum, right and left hemispheres; CER, cerebellum, right and left portions. Passing from one hemisphere to another is a white, broad, transverse band of fibres, like a bridge. This is the *pons Varolii* (bridge of Varolius), and is a bond of union between the various segments of the brain. Underlying it is the upper portion of the medulla oblongata. The cranial nerves are shown branching out from under the front and middle portions of the hemispheres, and from the sides of the medulla oblongata.

312. The Cranial Nerves. — Of these there are twelve pairs (Fig. 92), numbered from one to twelve in the order in which they rise from the base of the brain, the

enumeration beginning at the front of the cerebrum and continuing backwards. These nerves, with the exception of those distributed to the interior of the nose, eye, and ear (termed nerves of special sense), are either motor or sensory, or are mixed nerves and convey both sensory and motor impulses.[1] The fifth, seventh, and tenth pair of cranial nerves are briefly described in the three following sections.

313. The Fifth Pair of Nerves are the great sensitive nerves of the face and the side of the head. They possess also motor fibres (derived from distinct roots), which are distributed to the muscles of mastication. Each of the nerves of this pair has three main trunks. The upper one passes from the cranial cavity into the orbital cavity,[2] sending filaments to the eye and adjacent parts, then out through a notched opening in the skull underneath the eyebrow, toward its inner side,[3] and is distributed to the forehead and top of the head. The second branch, after leaving the cranial cavity, runs along the floor of the orbit, giving off branches to the upper teeth, gums, and mucous membrane of the upper jaw. Then, through an

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[1] First pair, *olfactory nerves*, or nerves of smell; 2d, *optic nerves*, or nerves of sight; 3d, *motor nerves* to three of the muscles that move the eyeballs, and to the iris and ciliary muscle of the eye; 4th, *pathetic nerves*, each of which moves one muscle of the eyeball, pulling the eyeball upward and outward; 6th, *motor nerve* to one of the straight muscles of the eyeball; 8th, *auditory nerves*, or nerves of hearing; 9th, *glosso-pharyngeal nerves*, nerves of sensation to pharynx, fauces, and tonsil, and special nerve of taste to certain parts of the tongue; the 11th joins the 10th, and is also distributed to muscles about the neck; 12th, *hypo-glossal nerves*, mainly to muscles of tongue.

[2] The cavity in which the eye rests.

[3] This point is very sensitive to pressure. Where the other branches of the nerve emerge, sensitiveness is less.

opening just below the front lower edge of the orbital cavity, it is distributed to the middle portion of the face, the nose, cheeks, and upper lip. The third branch, with

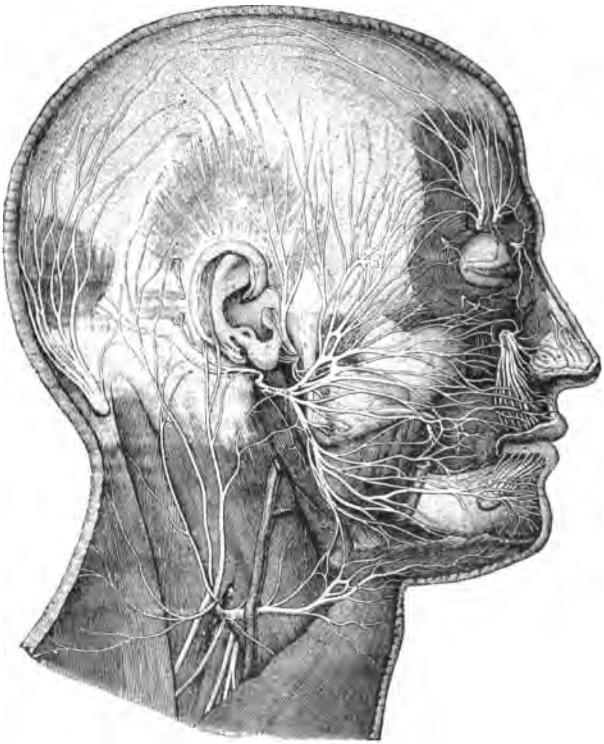

Fig. 93.
Superficial Branches of the Seventh and the Fifth Pairs of Cranial Nerves.

which the motor-nerve filaments are associated, supplies sensitive fibres to the mucous membrane of the cheeks, lips, and front part of the tongue, and to the lower teeth. It emerges at an opening in the front part of the lower jaw,

to be distributed to the lower lip, chin, and adjacent parts (Fig. 93). Irritation of this nerve by disease or other cause produces intense pain, as in neuralgia, headache, or toothache.

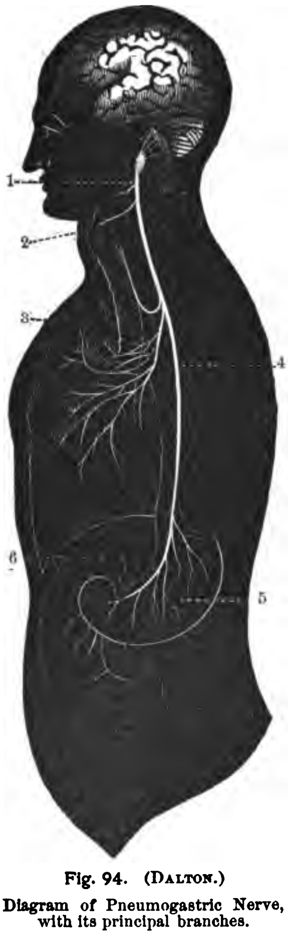

Fig. 94. (DALTON.)
Diagram of Pneumogastric Nerve, with its principal branches.

1, pharyngeal branch.
2, superior laryngeal.
3, inferior laryngeal.
4, pulmonary branches.
5, stomach. 6, liver.

314. The Facial or Seventh Pair of Nerves are the great motor nerves of the face, the nerves of expression, by which the features are animated by various movements, in response to the emotions. One nerve of the pair emerges from the skull near the external opening of each ear, and is distributed to the muscles of the face. When these nerves are irritated or diseased, convulsive twitchings of the face and unusual expressions result. If the injury is confined to the nerve of one side of the face, only the facial movements upon that side will be disturbed.

315. The Pneumogastric or Tenth Pair of Nerves are mixed nerves. Their distribution is wider than that of any other nerves in the body, and their influence greater, for they supply the organs of voice and respiration with motor and sensory impulses, and the pharynx, gullet,

stomach, and heart with motor influence. They are connected at various points with the sympathetic system of nerves.

316. The Spinal Cord extends downwards from the medulla oblongata about eighteen inches, and ends in a point opposite the second lumbar vertebra. It is a somewhat cylindrical mass of nerve tissue, and is fissured in front and behind. It becomes enlarged in the cervical and lumbar regions, at the points where the nerves supplying the upper and lower extremities are given off. Toward the lower end, it sends out prolongations through the sacrum which, from their fancied resemblance to the hairs of a horse's tail, are called the *cauda equina*.

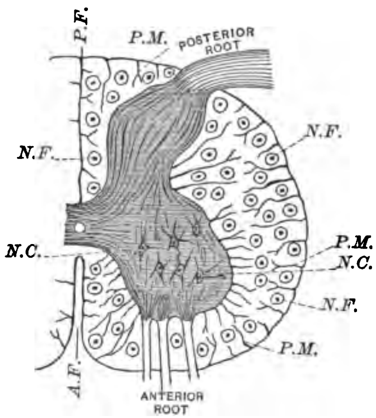

Fig. 95.

Transverse Section of One-half of Spinal Cord. (Partly diagrammatic.)

AF, anterior fissure. PM, pia mater.
PF, posterior fissure. NF, nerve fibres.
NC, nerve cells.

The centre of the spinal cord, for nearly its entire length, is composed of gray matter, arranged somewhat like two crescents (one in each half of the cord), united back to back by a band of gray matter. The extremities of these crescents, directed toward the front of the cord, are called *anterior horns;* those directed backward, *posterior horns*. Opposite them, at regular intervals, fibres of the spinal nerves emerge from the cord. The gray matter of the cord is surrounded by longitudinal nerve

fibres, which pass up and down the cord in well-defined tracts or columns. The white matter of the cord lying between the posterior horns and posterior fissure constitutes the right and left posterior columns; that between the posterior horns and anterior horns, the right and left lateral columns; that between the anterior horns and anterior fissure, the anterior columns. These columns are connected with fibres of the spinal nerves.

317. The Spinal Nerves consist of thirty-one symmetrical pairs of nerves, which are connected with the spinal cord by so-called *roots.* Each nerve has an anterior and a posterior root. The posterior roots (upon each of which is a ganglion),[1] with their respective nerves, are known as *sensory roots* and *nerves*, because they convey sensory impressions; while the anterior roots, with their nerves, are the *motor roots* and *nerves*, because they convey motor impulses. Just beyond or outside of their junction with their respective roots the motor and sensory fibres are inclosed in the same sheath, but their functions always remain distinct. The spinal nerves are mainly distributed to the skin and muscles upon the corresponding sides of the body, and convey nervous force and impressions to and from the trunk and the extremities.

318. Functions of the Spinal Cord. — The spinal cord is a conducting medium, as well as a nerve centre. The posterior columns of the spinal cord convey sensory impressions to the brain, and the antero-lateral columns convey motor impulses from the brain.

319. Sensory impressions, such as the perception of heat and cold, or of the size, location, and character of objects,

[1] Called sometimes spinal ganglion.

are conveyed by the sensory nerve fibres of the body to the sensory roots of the spinal nerves. By these roots they are conveyed either to the gray matter of the cord or to its posterior columns of the opposite side, to be transmitted by them to the cerebrum. *We become con-*

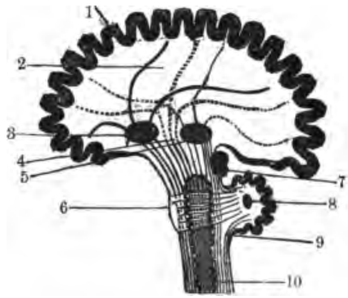

Fig. 96. (WESTBROOK.)

A diagram to represent the passage of the nerve fibres from the spinal cord upward to the different parts of the brain, and some of the more important ganglionic masses with which they are associated.

1, the gray matter of the cerebral convolutions.
2, the white matter of the interior of the cerebrum, through which the fibres pass on their way to the convolutions.
3, the *corpus striatum*, or anterior basal ganglion; the fibres passing through it run in three principal directions: viz., to the anterior, middle, and posterior regions of the cerebrum; they are represented by the three *continuous lines*.
4, the space between the two basal ganglia, through which fibres pass directly from below upward; these fibres appear in the cerebrum as *broken lines*, running toward the three principal regions.
5, the *optic thalamus*, or posterior basal ganglion, with fibres (represented by *dotted lines*) traversing it on their way from below upward.
6, the *pons Varolii*, made up of horizontal fibres which cross from one side of the cerebellum to the other.
7, *corpora quadrigemina*, from which the optic nerves, in part, take their origin.
8, the *cerebellum*, with a ganglionic mass in its interior, and fibres passing into it from the brain above and the *medulla oblongata* (9) below.
10, the dark convoluted line indicates the ganglionic matter of the spinal cord reaching up into the *medulla oblongata* and *pons Varolii*.

scious of sensations only when they are thus carried to the brain. If the posterior root of a spinal nerve is severed, irritation of the skin supplied by its fibres will not cause discomfort or pain, because that part of the skin is no longer connected with the brain. In proportion as an object becomes painful, whether by reason of great heat,

pressure, or other cause, the sensory nerves lose their power of enabling us to perceive the ordinary properties of the object, and we become aware only of suffering.

An injury to a sensory nerve in any part of its course is not felt at the point of injury, but at the *terminal points of the nerve filaments*, where impressions are usually felt. This explains why, when the ulnar nerve, or "funny bone," at the elbow is struck sharply, numbness or pain is referred to the outer side of the hand and the little finger, which parts are supplied by this nerve. Oftentimes, after a limb has been amputated, the patient claims that he suffers pain in the part removed, or that his toes or fingers, as the case may be, are being tampered with. The cause of this distress is generally found to be some irritation of the nerve in the wound. When the force of the nervous current is diminished in sensory and motor nerves by pressure, as when one leg is kept crossed over the other in a constrained position for a length of time, or the arm is lain upon in sleep, temporary numbness of the limb and loss of motion result, and the part is said to be asleep. Under such circumstances, attempts to move the arm or leg will prove futile for a minute or two, as the motor nerves supplying these extremities cannot act in obedience to the orders of the brain until they have regained their tone. The irritation of a motor nerve in its course results in motion of the part to which its filaments are distributed, while a severe injury produces loss of motion.

320. Motor impulses for the voluntary muscles originate, for the most part, in the gray matter of the cerebro-spinal nervous system.[1] From the cerebral gray matter

[1] The involuntary muscles are moved through the sympathetic system of nerves.

they are carried by motor-nerve filaments to the anterior columns of the spinal cord on the same side of the body, or to the antero-posterior columns on the opposite side, and thence to the motor nerves communicating with these columns.[1] From the gray matter of the cord, motor power passes out through the anterior horns, to be distributed by the motor nerves in connection with them. *Only those motions can be considered as voluntary which emanate from the brain.* If an anterior root of a spinal nerve be severed, motor impulses cannot be conveyed to the muscles usually moved by its nerve fibres when intact.

When the spinal column is fractured at its middle, the lower extremities are paralyzed, the upper remaining unaffected.[2] When the injury is in the neck region, the upper extremities are also paralyzed, for the cord is damaged above the point at which the nerves distributed to them are given off. Sometimes injuries to the spine result in loss of power only or sensation only; but, if severe, the parts below are deprived of both sensation and voluntary motion.

321. The Sympathetic Nervous System consists of a double chain of ganglia on the sides of the spinal column. These ganglia are connected with one another by nerves, and with the cerebro-spinal nervous system by motor and sensitive fibres. From them numerous and very delicate fibres are

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[1] Many fibres passing to and from the cerebral cortex pass through the basal ganglia. Of these, the *optic thalami* (one in each hemisphere) are believed to be sensory centres, and the *corpora striata* (one in each hemisphere), motor centres.

[2] Such paralysis is called *paraplegia*, while that which results in one side of the body, from injury to one cerebral hemisphere, is known as *hemiplegia*.

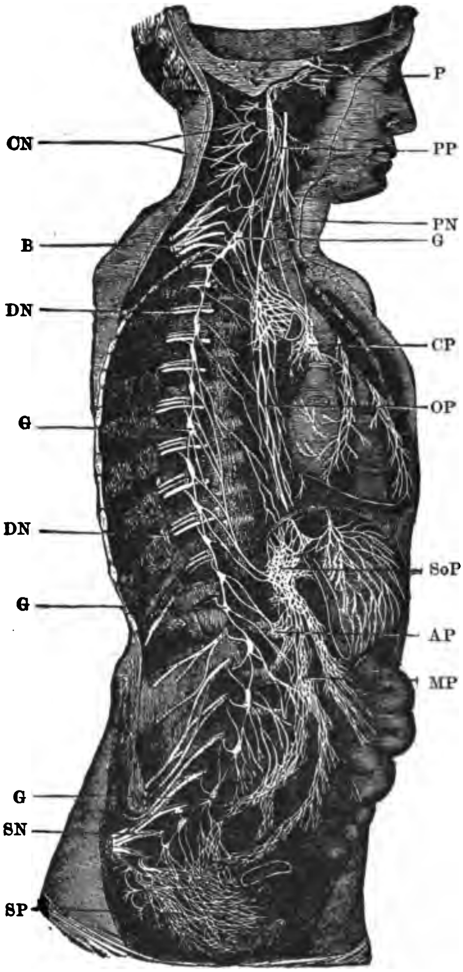

Fig. 97.

Vertical section of body, showing sympathetic nerves and ganglia of right side, and their connection with the cerebro-spinal nerves. — *Cerebro-spinal system:* CN, cervical nerves; B, nerves distributed to the arm; DN, dorsal nerves; SN, sacral nerves, some of which are distributed to the leg; PN, pneumogastric nerve. *Sympathetic system:* P, plexus in the head; PP, pharyngeal plexus; CP, cardiac plexus; OP, oesophageal plexus; SoP, solar plexus; AP, aortic plexus; MP, mesenteric plexus; SP, sacral plexus; G, some of the ganglia of the sympathetic system.

distributed, chiefly to the alimentary canal and its appendages, the heart, blood-vessels, and certain other organs.[1]

At various points the sympathetic nerves, with their ganglia, form matted nets, or *plexuses*, about certain large arteries. A typical one is the *solar plexus*, so called because its radiating nerves branch out like the solar rays. This is situated in the abdomen, some of its filaments accompanying the branches of the aorta distributed to the stomach, intestine, spleen, pancreas, liver, and other organs. An injury to this plexus, as by a severe blow upon the abdomen, is likely to result in sudden death. When persons are said to die of concussion or shock, death results from a severe disturbance of the sympathetic system. Soldiers have been known to die suddenly, without any mark of injury being found upon their bodies, from the passage of cannon-balls very near them. Squirrels and other small game are sometimes killed by bullets fired close to the head. Fish have been stunned or killed, when within a few inches of the surface of the water, by a sharp blow struck upon the water just above them, or by the close contact of a pistol ball.

322. Ordinarily, in health we do not notice that we have a heart, lungs, and stomach, so quietly does the vital machinery work. Yet, owing to the connection of the sympathetic with the cerebro-spinal nerves, the functions of the internal organs may be disarranged by apparently slight causes. For example, emotional disturbances, such as terror and fear, will contract the arterioles, and thus

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[1] These nerves, distributed to the blood-vessels, are known as *vasomotor* nerves, and the continuous muscular action they furnish is called the tone of the arteries.

cause paleness, while shame and joy will cause blushing by the dilation of these vessels. Even unpleasant sounds, odors, or events will sometimes interfere with digestion, the action of the heart, and the secretion of tears.

QUESTIONS.

1. How is man especially distinguished from the lower animals?
2. What is the use and general arrangement of the nervous system?
3. What two kinds of nervous tissue are there? What is their function? What are nerves?
4. Describe nerve force and its rapidity.
5. How is it aroused?
6. What three divisions has the brain? How are the brain and spinal cord divided longitudinally?
7. Name and describe the three coverings of the brain and spinal cord.
8. On what does the working capacity of the brain depend?
9. Describe the cerebrum and its hemispheres. What do the convolutions indicate?
10. What relation do the hemispheres bear to each other and to the body?
11. What is the office of the cerebrum? of memory? of judgment and reason?
12. What effect has mental exercise upon the cerebral substance?
13. Describe the cerebellum and its function. The medulla oblongata.
14. State the importance of the medulla oblongata. How is it protected?
15. Describe the spinal cord; its conveyance of sensations and motor impulses.
16. What are the spinal nerves? Which of their roots convey sensations? which motor impulses?
17. How are sensations conveyed to the brain?
18. How is motion produced? where originated? How is the motor impulse transmitted?
19. What is the effect of irritating nerves midway in their course?
20. What follows the severing of nerves or of the spinal cord?
21. How many and what are the cranial nerves? Whence do they issue?

22. How many and what branches has the fifth pair? What causes toothache?
23. What pair constitutes the facial nerves? What follows their use? their injury?
24. Describe the tenth or pneumogastric nerve.
25. Describe the sympathetic system, and its ganglia and plexuses.
26. Over what processes does this system preside? What is its normal action? What may ensue from a sudden shock to a plexus?

CHAPTER XVI.

NERVOUS SYSTEM (continued).—REFLEX ACTION.—NERVOUS ENERGY.

323. Reflex Action. — Many of the movements of our bodies are automatic. These are the result of what is known as *reflex action*, *i.e.* an action (secretion or muscular movement) produced by the transmission of an afferent impulse to a nerve centre and its reflection thence as an efferent impulse. In some way a sensory current, received by certain nerve cells, stimulates other nerve cells to produce a motor current. Reflex action is especially distinctive of the gray matter of the spinal cord, which is a long series of nerve centres. Other movements that are sometimes called automatic, such as walking and eating while we are in deep thought, are first started by the will, and then continued apparently by reflex action through the cerebellum or spinal cord.

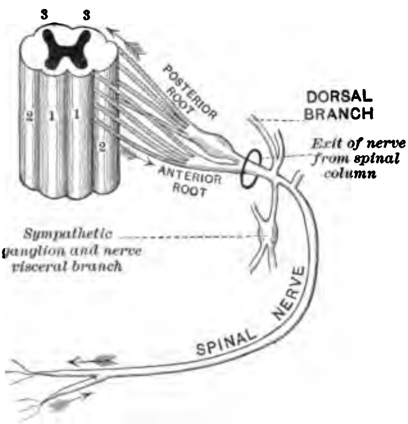

Fig. 98.

Section of Spinal Cord and Diagram of Spinal Nerve, motor fibres ending in muscle of abdomen, sensory fibres beginning in skin overlying the muscle.

1, 1, anterior columns. 2, 2, lateral columns. 3, 3, posterior columns.

For the performance of reflex action, it is essential that the continuity of the sensory nerve be intact between the terminal point irritated and the nerve centre, that the nerve centre be healthy and uninjured, and that the continuity of the motor nerve be intact from the nerve centre to the glands or muscles acted upon.

324. Examples of Reflex Action.—If the spinal cord be severed at any point, the power of *voluntary* motion is at once lost in all parts below that point. But if the reflex activity of the spinal cord below the severed portion remains intact, and the foot be tickled, the foot and leg will be hastily drawn away. In the same way a hand or foot accidentally coming in contact with a hot substance is instantly snatched away before the brain has had time to take cognizance of the danger. The instinctive efforts made to hold or regain one's footing, when jostled in a crowded conveyance or slipping upon the pavement, are also due to like reflex impulses. If the spinal cord is inflamed, or is under the influence of strychnine or any other stimulating substance, the sensitiveness of the gray matter of the cord to impressions is greatly increased. In such instances convulsions readily occur by contact of the body with a draught of air, or by the noise caused by the sudden shutting of a door. In cold-blooded animals, the reflex activity of the cord remains for a considerable length of time even after the brain has been removed and the animal is practically dead. A decapitated frog will jump in a natural manner when the feet are pinched or irritated.

325. For the most part, reflex action is performed without the knowledge of the individual, but it sometimes may be voluntarily aided. Swallowing, ordinarily

the result of unconscious reflex action by contact of substances with the pharynx, becomes voluntary if a substance lodges in it. A minute particle lodging in the larynx, by its irritation induces coughing and involuntary efforts of this organ for its expulsion. These, if unsuccessful, are aided by the voluntary efforts of the individual, sometimes many of the muscles of the body uniting to get rid of the insignificant particle. The act of winking is the result of a reflex action, and occurs generally without our knowledge, but may also be performed at will.

326. There are certain reflex actions effected through the cerebro-spinal nerves, in conjunction with those of the sympathetic system, of which we are conscious, but over which we have ordinarily no control. Of these may be mentioned coughing, vomiting, blushing, the secretion of tears from irritation of the eyes by dust, the closure of the eyelids at a sudden flash of light, and the grimace on suddenly inhaling an unpleasant odor.[1]

327. The Reflex Actions of the Sympathetic System we are not even conscious of, except in some diseased conditions of the body. Such actions result in secretion, excretion, absorption, peristaltic movements, the contraction and dilatation of the pupil of the eye in regulating the admission of light, and the variations from time to time in the volume and rapidity of the blood current in the numberless capillaries of the body.

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[1] Sometimes pressure upon the upper lip will prevent sneezing, and diversion of the mind by new scenes or objects may stop an irritating cough, or even prevent vomiting. A surgeon, after taking an active emetic, was almost immediately called upon to perform an important surgical operation. Not till after the operation was performed and the anxiety was over did the emetic take effect.

328. Sometimes during sleep voluntary actions are performed without the mind's being conscious of them, even of their inception; such, for example, are walking and writing, or even intellectual efforts of a high order. Sleep-walkers, or somnambulists, have been found carefully balancing themselves on the ridges of housetops, or engaged in other perilous feats. To awaken them suddenly, and so disarrange the nervous control of the muscular movements, may prove dangerous.

329. Artificial Reflex Actions: Habits.—The voluntary faculties may be educated to act, as it were, in a reflex manner. Actions which at first are purely voluntary and consciously performed may, by frequent repetition, become habitual and apparently be performed unconsciously. Such actions are common, and are called *artificial reflex actions*. The expert pianist plays the most intricate music without any apparent thought upon his part as to how his fingers are to move; and it is a common experience for persons to walk, eat, and even read in an automatic manner while their thoughts are occupied by other matters.[1]

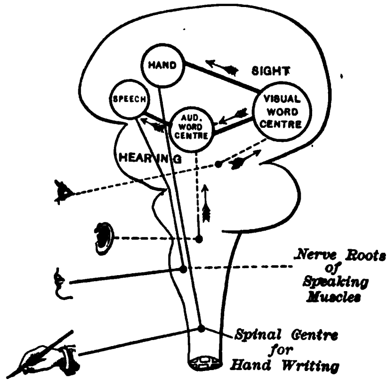

Fig. 99. (Brown.)
Nerve Centres in Relation to Speech and Writing.

[1] It is said that a soldier, while carrying a bowl of soup, suddenly dropped it, on hearing some one call "attention," so accustomed was he at that word of command to stand erect with his hands by his sides. Con-

Children, by imitating the odd habits or actions of others, sometimes acquire similar habits, which may be very difficult for them to eradicate.[1]

330. The Use of Reflex Actions. — Were it not for reflex actions, every movement of the body and all the functions of the internal organs would have to be planned by the cerebrum. Harmonious coöperation of the various parts of the body would be impossible, and the mind would be so overburdened with details that there could be no intellectual development. It is only in some disordered or diseased condition of the body that we appreciate any irregularity or want of harmonious nervous action. Hence it is that the healthy, robust man or woman often fails to have any sympathy with the ailing person subject to irregular reflex nervous actions which cause pain, uneasiness, nausea, and discomfort.

A strong will may control many of these actions, and a weak one is more or less controlled by them. For example, the reflex action of crying out when in pain is sometimes prevented by biting the tongue, clenching the teeth, or by holding some object very tightly. So, too, the yielding to the sensation of tickling, or to the involuntary closing of the eyes when a blow is aimed at the head, may, in a similar way, be prevented. But Mr. Darwin

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valescing soldiers in military hospitals have been known to jump out of warm beds and stand erect, at hearing the word "attention" shouted in through the door by a would-be joker. A gentleman, accustomed to eat apples while reading, often reached out his hand for an apple while his thoughts were busy on the book. One evening a friend, unperceived, added a number of apples to those already in the dish; and the reader unconsciously ate apple after apple until all were gone.

[1] The unconscious performance of ordinarily conscious actions has been termed "unconscious cerebration."

gives a striking example of an instinctive reflex act overriding a very strong effort of the will: "He placed his face against the glass of the cobra's cage, in the reptile house of the Zoölogical Gardens, and though, of course, thoroughly convinced of his perfect security, could not, by any effort of the will, prevent himself from starting back when the snake struck with fury at the glass."

In young children the nervous system is delicate and very susceptible to impressions. Reflex actions are especially frequent, and sometimes attended with danger, in children of excitable temperaments and those who have a tendency to nervous disorders. In such children, indigestible food, dentition, or fright may cause convulsions, epilepsy, or even death.

331. Nervous Energy.—The quantity of nerve force and the amount of nervous energy which each person possesses cannot be definitely stated. Most individuals have more than is required for the ordinary necessities of life. The surplus constitutes a reserve force, which is stored away for emergencies. In times of trial, feeble and apparently inefficient persons sometimes have more nervous energy than those whose ordinary physical powers are much greater; while, on the other hand, persons of robust appearance may prove almost valueless on such occasions.

Some persons, especially those not in robust health, are particularly susceptible to nervous impressions, and in them the reserve nervous force is likely to be recklessly drawn upon. Even persons of strong physical and mental powers, who do not readily succumb to the effects of various forms of dissipation, and who freely indulge in excessive exercise, over-eating, over-drinking, or late hours, may unduly tax their reserve supply of nervous force, while

believing that they are too strong and well to be affected by the drain. The persistent overtaxing of our powers, whether mental or physical, will sooner or later exhaust the nervous system, and reduce us to mental and physical bankruptcy (*a*).

332. Perverted Nerve Force: Nervousness. — Disease, the excessive concentration of the thoughts upon one's self, severe mental or physical work, and, above all, worry, especially if associated with lack of rest, of pure air, and of suitable food, create a disturbance or perversion of nerve force, even in those who are considered strong, mentally and physically (*a*). Such perversion produces nervous prostration and hysteria (*b*), attended by over-sensitiveness of various parts of the body, or a numbness or diminished sensitiveness. There is also increased excitability of the emotions, with a tendency to spasms of voluntary and involuntary muscles, and to sudden congestions of blood.[1]

333. Hygiene of the Nervous System. — Many of the nervous disturbances to which all are more or less subject can be warded off and nerve force and energy strengthened by systematic and proper exercise and rest of the nervous system, just as muscles and other organs are developed by regular and appropriate exercise and rest. Exercise improperly adapted, however, to the age, health, and condition of the individual results in a loss of nerve power. Like other parts of the body, the nervous system

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[1] To say that one is nervous too often means that the person of whom it is said is weak-minded and has lost self-control, due to thinking too much of himself, rather than of the welfare of others. The use of the term as an excuse for failure to do one's duty is very common.

needs also for its maintenance and health sufficient and wholesome food, and all other hygienic necessities.

The brain, usually, has not more than *one-fortieth* of the weight of the body, yet it receives about *one-fifth* of the whole volume of the blood. This large proportion of blood indicates that the brain is intended for active work; but its working capacity, like that of other organs, is dependent not only upon the quantity, but also upon the quality, of the blood which it receives. If it is ill developed or badly nourished, sensations and will power will be feeble. If one faculty or set of faculties has been overtaxed, rest and the use of other faculties instead are demanded. The most vigorous intellect is generally found in the most evenly developed body; and so closely are mind and body related that if the health of one fails, that of the other, also, is likely to be impaired.

Mental labor in excess is, contrary to the belief of some persons, as exhausting as excessive physical labor, and cannot, as a rule, be pursued for so long a time. The amount of nervous energy which each person should expend depends upon the capacity of the individual. No person, however, *should work up to the full measure of his ability*. Such work is attended with danger, and has been responsible for the death of many otherwise intelligent persons. Moderate labor, regularly and systematically pursued, will accomplish more than any amount of spasmodic effort, and will not be attended with such danger to the system. As far as possible, therefore, regular mental and nervous work should supersede irregular work, and monotonous labor be replaced by varied exertion, if we are to gain and maintain a sound mind in a sound body. Gradually increasing and systematic mental work, proportionate to the health and nervous power,

does not pull down the average man. It is the spasmodic overwork in the struggle for wealth or fame, the perplexities which result from suddenly assuming duties one is not capable of performing without a course of preparatory training, that do the mischief. The worry which all such work excites is a bar to sound mental and nervous health, and is oftentimes the factor which turns sanity into insanity.[1] In the turmoil and bustle of modern life, especially in our large cities, the danger to the nervous system is great. The remedy is to practise self-control, for "he that ruleth his own spirit is greater than he that taketh a city." One cannot afford to be unstable, to shift from fancy to fancy, if he wishes his brain to act promptly, vigorously, and intelligently.[2]

334. Effects of Alcohol and Narcotics on the Nervous System.—The tendency of the indulgence in any form of

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[1] The chief enemies of the brain are worry, which disorganizes the machinery, and shock, which paralyzes the brain. "Worry or excitement causes irregular nerve action; we call it confusion of ideas, or nervosity. The optic brain centres throw up a series of depressing mental photographs, exaggerating existing trouble. This continues to depress the cells in the fore-brain, resulting in complete failure to judge aright or analyze correctly. Slight annoyances are likely to grow into quarrels in this way, for by brooding over them brain fatigue occurs. Then the imagination sees exaggerated views, until spite and hatred and kindred passions exhaust the fore-brain, and misguided actions result. The stronger the quarrel grows, the weaker the finer perceptions become. This explains the disease of the age—worry—and its results."—DR. ALBERT WILSON, *The Brain Machine, its Power and Weakness.*

[2] "Who is brave? He that masters his passions. Who is free? He that has self-control."

"Teach them to strive after self-effacement, to aim at some higher ideal than themselves, subsequently to find in labor, strength, and through suffering, tranquillity, and so transfigure their lives to discover therein sacrifice instead of selfishness, and gladness instead of gloom."

alcoholic drink is to interfere with the various functions of the nervous system and the parts of the body dependent upon it for activity, and to weaken, and at last destroy, the control of the moral nature. These effects are not understood by people in general. "The gradual changes induced in the nervous system, the slow poisoning of the great centres of thought,—the transmission from parent to child, from generation to generation, of nervous tendencies, progressive mental weakness, imbecility, insanity, idiocy,—are evils which far outweigh the results of the midnight brawl, the mother's sorrow, and the orphan's tears." As a medicine, alcohol should be dealt with like opium,—that is, recognized as an agent which, unless properly employed, will do harm instead of good. Like tea and coffee, it ranks as an excitant or stimulant, but its effects on the nervous system are unlike those of tea and coffee, since it must be taken in gradually increasing amount to afford the desired effects, and little by little an "alcohol habit" is formed. This tendency of moderate drinking to become immoderate is tersely expressed by a Japanese proverb, "*A man takes a drink, the drink takes a drink, and then,—the drink takes the man.*"

An alcoholic is first used as an experiment, or to please a friend,[1] then comes the feeling of necessity for it, a craving that gradually demands a larger amount. It is used more frequently, until body and mind are poisoned by it. This is the history of most drunkards. When a man loses control of himself from the effects of alcoholics, when he lies and resorts to the basest of tricks to obtain a drink, when his judgment becomes clouded, and his evil

[1] The custom of treating to drinks is unfortunately an American one, and unbiassed students of the evils of alcoholic intemperance in this country agree that it is largely responsible for such intemperance.

passions assert themselves, when he is no longer a reputable member of society, he must be considered a diseased person, and should be removed to an asylum or reformatory for treatment.[1] This is the only chance for a cure. Life-insurance companies consider persons subject to the drink habit as "extra hazardous risks." Great business interests of this country recognize that alcohol unfits men for doing the best work, and will not employ persons addicted to its use. Professional athletes, such as prize-fighters, ball-players, and oarsmen, understand that they must stop drinking if they wish to excel. Experiments show that more than thirty per cent of muscular strength is diminished by the use of alcohol,—*i.e.* that the nerve power which operates muscles is diminished.

Briefly, the recognized effects of alcohol on the nervous system are as follows: 1, excitation of the functional activity of the brain, and later of the spinal cord and sympathetic system; 2, a general lack of coördination,—the tongue refuses to give correct expression, ideas are confused, mental hallucinations[2] and even insanity may result. This state is followed, or may be accompanied, by vasomotor paralysis, impaired reflex action, depression, coma, and even death. Many of these conditions are due to degenerative changes in the nerve cells, and to thickening of the nervous connective tissue.

"Alcohol makes the person who indulges in it believe

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[1] In England, on January 1, 1899, the "Inebriates Act" went into operation, giving magistrates the right to sentence criminal habitual drunkards to a reformatory instead of to a penal institution. Australia has a similar law, and legislation to the same effect is being brought about in this country,—a step in the right direction.

[2] Viz., delirium tremens. Excellent authorities agree that *dipsomania*, or intense craving for alcohol, is frequently an hereditary neurosis, *i.e.* a disease of the nervous system.

his condition is very different from what it really is. . . . While he may believe that his senses are keener and his powers of endurance greater, experiments with scientific instruments of precision have demonstrated that his acuity of vision is lowered, his power of hearing reduced, his sense of smell blunted, and his taste so obtunded that he can swallow fiery and even caustic liquids without wincing, and his muscular strength, which he believes to be greatly augmented, is shown by the dynamometer to be materially reduced. Even his soul-stirring eloquence and poetic flights are largely discounted in the estimation of the man who has not been imbibing."

335. *Tobacco* is a narcotic, but used occasionally, in small amount, may be a stimulant. The tobacco habit, by inducing lassitude and an indisposition to exertion, may cripple one's energies, and unfit him for the necessary competition of business life.

336. *Opium*, *chloral*, *cocaine*, etc., are essentially narcotic drugs, and what has been said as to the causes and effects of the alcohol habit may be said even more strongly in regard to those of the opium, chloral, and cocaine habit. The moral deterioration from the frequent use of these drugs is even greater than that from alcohol.

To sell liquor to minors or to persons already under its influence and to sell narcotic drugs without the prescription of a physician should be criminal offences.

QUESTIONS.

1. State the three conclusions at the commencement of this chapter.
2. What is reflex action?
3. Give an example of a really automatic action, and of an apparently automatic one.

4. Give examples of reflex action of the spinal cord; of one aided by the will; examples of reflex action of the sympathetic system.
5. Of what value are reflex actions?
6. When are reflex actions recognized by the person in whom they occur?
7. What is said as to the quantity of nerve force and nervous energy which each person possesses?
8. What is meant by perverted nerve force?
9. How can the nervous system be kept in good working order?
10. What is said as to the proper use of nervous energy?
11. What is the value of self-control?
12. What are the effects of alcohol on the nervous system? on the moral nature?
13. What are the effects of opium, chloral, etc., and of tobacco?

CHAPTER XVII.

SENSATIONS.—THE SENSES: TOUCH, TASTE, AND SMELL.

337. Common and Special Sensations. — By means of *sensations*, the mind obtains a knowledge, first, of the condition of the various parts of the body; and, second, of external objects and phenomena. The first-named class may be termed *common sensations;*[1] the second, the *special sensations*, or the *senses*. Under the first head are those which cannot be distinctly localized, such as fatigue, discomfort, faintness, and also itching, creeping, tickling, aching, and burning.

Tactile sensation constitutes what is commonly known as the sense of touch. The line of demarkation between many of the common sensations and this sense is not a clear one. In fact, as Kirke[2] says, "though touch is usually classed with the special senses, . . . it forms the connecting link between the general and special sensations." The sensations produced by stimulation of the nerves of the skin and of certain portions of the mucous membrane are numerous. Of these may be named the sensations of ordinary touch, of weight, heat, cold, and tickling, and, if the stimulation is strong, of pain. Some parts of the skin are more sensitive to certain impressions than to others, and at times one sensation in a part is experienced after others are lost. Pain is

[1] Sometimes called general sensations. [2] *Handbook of Physiology*.

probably more easily induced in the face than elsewhere. The cheeks and ears seem to be more sensitive to the changes of atmospheric temperature than other parts of the face. The soles of the feet, the knees, and the armpits are particularly sensitive to tickling. The power of distinguishing heat and cold may be lost in a part, as in paralysis, and yet the sensations of touch and pain remain; or pain may be prevented by anaesthetics before the sensation of touch disappears.

338. Muscular Sensations, or Sense. — The sensation of weight, resistance, etc., is called by some physiologists *the muscular sense*, from a belief that to a great extent it is dependent upon the muscular nerves, and is, therefore, a peculiar property of muscles. It is most developed in those parts of the body where the tactile sensibility is the keenest, and is probably due to the relative amount of the pressure of bodies upon those parts, and also to the relative amount of nervous and muscular energy expended in sustaining or resisting bodies. It is an aid in enabling us to appreciate the "resistance, immobility, and elasticity of substances that are grasped, or on which we tread, or which by their weight are opposed to the exertion of muscular power." Habit and education have a great deal to do with this sensation. It is astonishing with what accuracy experts will detect a departure from the standard weight in handling barrels of flour and other packages, or even in such light articles as coins.

339. Pain. — Fortunately, in health, *the application of stimuli beyond what may be considered in each individual the natural limit of stimulation is attended by discomfort or pain.* For example, tickling may not be unpleasant at

first, but if persisted in, it is likely to become exceedingly disagreeable and painful, and may be carried to such a point as to be dangerous. "The muscles, though they are not very sensitive organs to ordinary stimuli, yet when contracted spasmodically occasion severe pain. They ache when fatigued, and pain is felt when they are contused or cut." Sunlight, so necessary for health and comfort, if intense and shining into one's eyes, will produce pain and blindness. Similarly, long-continued and high-pitched sounds fail at length to be appreciated as sounds, and produce only painful sensations. This sensibility to pain guards us from many and great dangers. Those parts of the body which are the most subject to injury are supplied with nerves in the largest quantity, and are most sensitive. A cut into the skin, or the application of an irritant, ordinarily causes pain; but the structures beneath the skin are comparatively insensitive.[1]

340. Were it not for this sensibility to pain, important parts of the body might be irreparably injured without the knowledge of the individual. Thus, the skin might be almost boiled by the hot water of a bath, or the eye might become intensely inflamed by long exposure to bright sunlight, if pain did not warn us of the danger. This sensibility undoubtedly differs in degree in both men and animals.

341. The Senses. — The *special sensations*, or *the senses*, are generally spoken of as five in number; viz., touch,

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[1] In a surgical operation, cutting through the skin is the most painful step, but this pain is very frequently diminished or avoided by the application of cold to the part, by means of ether spray or other quickly evaporating material.

taste, smell, sight, and hearing.[1] All the organs of special sense are, however, but the *working tools of the brain.* Hence, not only should they be perfect in structure, but also the brain, and the special nerves which connect these organs with the brain, should be in an alert and healthy condition.[2] During deep sleep, impressions of sound may be presented to the ear, or of chilliness to the skin, and they will not be perceived. During the sleep usually produced by anaesthetics, great surgical operations are performed without the knowledge of the individual operated upon. But when the sleep is not profound, the various steps of an operation may be recognized and afterward remembered, though the ability to move and the perception of pain may be absent.

It is to be especially noted, first, that each nerve of sense is capable of performing only the function designed for it; the nerve of sight does not enable us to hear, and the nerve of smell enables us to appreciate only odors. Second, that cultivation of the senses, especially if begun in early life, will develop their usefulness. Cultivation furnishes the accurate hearing of the educated musician, the keen eyesight of the pilot, engineer, and expert microscopist, and the accurate touch of the blind (*a*). But the training may be carried to the extent of making these senses sources of

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[1] Some physiologists, believing that the several sensations produced by stimulation of the cutaneous nerves, and of those of certain portions of the mucous membrane, are effected through distinct sets of nerve fibres, enumerate as among the senses the sense of pressure, of temperature, of pain, etc. Others claim that all the senses are but modifications of the sense of touch.

[2] As sight, hearing, and touch seem to be most concerned with the wants of the intellect, they are sometimes spoken of as the *intellectual senses;* while taste and smell, being intimately connected with nutrition, are known as the *corporeal senses.*

misery. Certain persons are painfully conscious of the slightest discord; others almost instantaneously detect, with a feeling of disgust, the inharmonious blending of tints which, to the average person, are all in harmony; still others are made uncomfortable by an odor perceptible to no one but themselves.

342. Touch is that provision by which we appreciate, by actual contact, the size, form, and character of the surface of objects. It is most sensitive where the nerve endings are the most numerous and their covering the thinnest, as in the margin of the lips, tip of the tongue, palms of the hand, and under surface of the fingers. It is least acute in the middle of the back.[1]

343. The human hands, with their long, flexible fingers and adjustable thumbs, with their beautiful adaptation to the wants of the whole upper extremity, and with their average of 20,000 papillae to each square inch of surface, are the parts of the body most usually employed in the exercise of the sense of touch.[2] The sensitive tips of the fingers enable us to feel accurately, while their protection by epidermis, nails, and cushions of fat save us from

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[1] The delicacy of the tactile sensation may be measured by lightly applying at one time the two points of a pair of compasses to any part of the skin, the eyes being closed. In proportion as the parts tested are sensitive will the two points be perceived as two points when brought very close together. In this way it has been ascertained that the palmar surfaces of fingers and hands are more sensitive than the dorsal surfaces, the front of the body than the back.

[2] In the cat and seal, feeling is in part effected through the long bristles upon the lips, which are connected at their bases with nerve papillae. In some monkeys the extreme end of the tail, and in the elephant the trunk, are organs of touch.

much of the pain that would ensue, if the fingers were not so protected. If the cuticle is removed and the ends of the sensitive nerves are exposed to the air, pain results, and the sense of touch is lost.

344. Touch is the simplest of all the senses, and the one which is apparently first developed in the infant. Simple as the sense is, it is capable of wonderful development, especially in persons deprived of one or more of the other senses. The blind learn to read by means of slightly raised letters or points, and to recognize persons by feeling their faces. They distinguish by touch different plants, the minute markings upon precious stones, the delicate tracery upon works of art, and, assisted by the sense of smell, even the color of fabrics.[1] They may become expert musicians and good sculptors; for it is related of the blind sculptor, Giovanni Gonelli, that he could model the most striking likenesses, entirely by the sense of touch.

Physicians, by practice, acquire the *tactus eruditus*, or discriminating touch, which is so valuable in detecting any unusual thickening, swelling, or heat of parts.[2] The expert pianist acquires the ability to strike with precision many keys in a few seconds of time.

345. Taste is the sense by which we discover and recognize the flavors of substances. It is made possible through

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[1] It is said that a blind country merchant was in the habit of selecting shawls and dress goods for various customers, whenever he went to the city for stock, and that he seldom failed in taste and judgment.

[2] A well-known surgeon, now dead, performed the most delicate operations, which required the keenest sense of touch, though his hands were very large and clumsy-looking.

the mucous membrane of the tongue, of the soft palate, and of the back part of the throat, these being, in fact, the organs of taste. The tongue is also an organ of touch, and being composed of muscles capable of moving it in various directions, it is well adapted to bring material to be tasted in contact with all parts of the mouth.

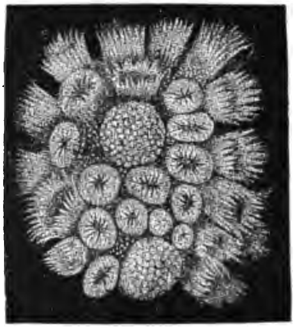

Fig. 100.
Papillae of the Tongue. (Magnified 20 diameters.)

The mucous membrane of the tongue is especially adapted to the detection of flavors. It is abundantly supplied with both vascular and nervous papillae, similar to those of the skin. There are, in addition, large compound papillae on the back part of the tongue, arranged in a V-shape, and also smaller ones toward the front part. The papillae are covered with a delicate plush-like epithelium, permeable by fluids.[1]

346. The tongue possesses, as we have seen, general sensibility; but the sense of taste has no distinct nerve, as in the case of the senses of sight and hearing. The lingual or gustatory branch of the fifth pair of cranial nerves supplies about two-thirds of the tongue, while the lingual branch of the glosso-pharyngeal is distributed to

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[1] Some of the filaments of the nerves of taste end in the papillae in enlargements known as taste buds, or taste goblets. Some of the filaments probably end in the epithelium, but the sense of taste is most acute where the buds are numerous. If the glosso-pharyngeal nerve is severed, degeneration of taste buds ensues.

the posterior third. These nerves convey sensations of taste to the brain. The tip of the tongue seems to pos-

Fig. 101. (DALTON.)
Diagram of Tongue, showing the nerves and papillae, and by dotted lines the direction of the muscles.

sess the greatest sensibility to savors; the base is less sensitive, and the sides least of all.

347. *Only those substances can be tasted which are dissolved.* These by endosmosis penetrate the mucous membrane, thus reaching the nerves of taste. Dry sugar or salt, placed upon the tongue, is not tasted till it begins to dissolve. The finer the comminution of food, the sooner is it tasted. The dissolving process is much facilitated by the varied movements of the tongue.

348. Taste is one of the means by which we distinguish between proper and improper articles of food. But in determining the nature of such articles, it is assisted by the other senses. Undoubtedly much pleasure is lent to the taste of certain substances by their appearance and odor. A cold in the head will interfere with the taste. The practice of swallowing disagreeable medicines with the nostrils closed is quite common. It has

even been affirmed that, if the nostrils are closed and the eyes shut, the taste of an onion may be mistaken for that of an apple. The sense of taste, which in man is naturally more acute than that of smell, is more easily perverted. In some of the lower animals — dogs, for example — the sense of smell is more acute, and these animals generally smell before they taste.

349. Such qualities as watery, astringent, viscid, oily, burning, mild, and sharp are appreciated by the ordinary sensory nerves. Sweet and sour qualities are best appreciated by the gustatory nerve at the front of the tongue; salt and bitter qualities, by the glosso-pharyngeal nerve toward the back of the tongue.[1]

350. Taste in the human being, and also in some of the lower animals, is more or less influenced by imitation, habit, surroundings, and training.[2] The young baby does not readily distinguish between the taste of oil and that of sugar, but learns the difference by degrees. Children fancy certain articles of food and dislike others, because other members of the family or their schoolmates do the

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[1] "Sweet, bitter, sour, and salt are the four tastes with which it is supposed the taste buds have to do. There is also an alkaline and perhaps a metallic true taste. A tap on the tongue may excite a taste. A "constant" current of electricity through the tongue produces acidity at the positive pole and alkalinity at the negative. . . . Rinsing the mouth with very hot or cold water is said to blunt the taste of quinine. Certain diseases produce tastes. Biliary products retained in the blood give a bitter taste to the mouth, and in diabetes the mouth sometimes has a sweet taste."

[2] When tomatoes were first introduced into this country, they were generally disliked. Many a man who will not eat fat salt pork at home will relish it at sea or in the army.

same. Persons living in malarious regions have been known to like the bitter taste of quinine. Inhabitants of certain parts of the world enjoy rancid fats. Morbid tastes are sometimes the result of disease, or disorders of the brain or of the blood. Persons so afflicted will eat with avidity slate pencils and plaster, or drink vinegar. That taste may be developed, especially when assisted by the sense of smell, is seen in expert tea and wine tasters. The too frequent tasting of strong condiments or spices blunts the sense of taste for more delicate flavors, just as the frequent tasting of any one article dulls the taste for others. The nerves of taste fully appreciate but one flavor at any one time, so that if one is presented before another has disappeared, the result is a mixed or confused taste.

351. Smell. — In man the *sense of smell* is not so acute as the other senses, and its impressions often need to be confirmed by the others (*a*). In dogs, on the contrary, it is very acute, enabling them to track their prey or find their masters by scent alone. It is said that the Esquimaux dogs in the Arctic regions are of great value, because they can detect, by the sense of smell, supplies of food stored in the ice long distances away. By this sense animals also detect the presence of pursuers, if the latter approach from the windward side.

352. The essential organ of smell is the upper half of the mucous membrane of the nasal fossae, or nose cavities.[1] These are separated from each other by a verti-

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[1] The lower part of each nasal cavity is the respiratory part; its epithelium, like that of the trachea, consists of ciliated cells. The upper portion is the olfactory part; it has no ciliated cells, but has many rod-shaped cells, in which the filaments of the olfactory nerves end.

cal wall of cartilage and bone, called the *septum*. In the mucous membrane which covers part of the septum and on the two upper turbinated bones are distributed the terminal filaments of the *olfactory nerve*, or nerve of smell. These filaments come through the roof of the fossae, as through a sieve, from the olfactory bulbs, which are the

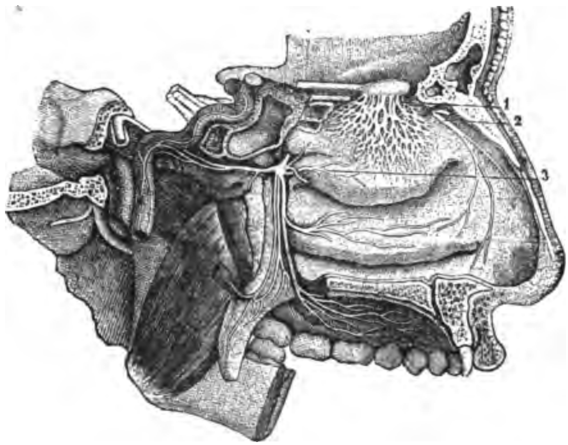

Fig. 102.

Left Nasal Cavity.

1, left olfactory bulb with its nerve branches. 2, the nasal nerve. 3, a ganglion, and nerves of the sympathetic nervous system.

terminations of the olfactory nerves. These bulbs lie under the anterior portion of the cerebrum and upon the bony floor of the cranial cavity (Fig. 102). The lower half of the mucous membrane of the nose is supplied with ordinary sensibility by a nasal branch of the fifth pair of cranial nerves. Its irritation causes sneezing.

353. Odors, to be recognized, must be presented in a gaseous or vaporous form to the mucous membrane containing the olfactory nerve filaments. The most minute

portion of such a substance as musk will be readily perceived, if it be forcibly drawn up during inspiration into the higher portions of the nasal fossae. Some persons are so susceptible to odors and emanations that the smell of certain substances — of roses, for example, or of new-mown hay, or of certain drugs in a powdered state — may excite in them an inflammation of the nasal passages.[1] Sharp and pungent vapors, such as that of ammonia, are perceived by the lower portions of the nasal passages (*a*).

354. The sense of smell may be highly developed, especially where there is deficiency in other senses.[2] Certain blind and deaf mutes are able to recognize by the sense of smell any person with whom they have previously come in contact. Dryness of the nasal mucous membrane, or its frequent irritation, tends to blunt the sense of smell.

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[1] Hay-fever is one form of such inflammation.

[2] "Taste is at the gateway of the alimentary canal, just as smell is the sentinel of the respiratory tract; and just as taste, when combined with smell to give the sensation we call *flavor*, influences the digestive process, and is influenced by it, so smell influences the respiratory process. This has been recently shown by Ch. Henry. He has recorded the entrance and exit of air by the nose with and without odors (the quantity of odoriferous substance being noted), and he finds that the presence of odors influences both the amplitude and the number of the respiratory movements. Thus the smell of wintergreen notably increased the respiratory work; next came ylang-ylang, and last, rosemary. The breathing of a fine odor is therefore not only a pleasure, but it increases the amplitude of the respiratory movements. Just as taste and flavor influence nutrition by affecting the digestive process, and as the sight of agreeable or beautiful objects and the hearing of melodious and harmonious sounds react on the body and help physiological well-being, so the odors of the country, or even those of the perfumer, play a beneficent rôle in the economy of life." — Dr. John Gray McKendrick and William Snodgrass, *The Physiology of the Senses.*

355. Effects of Alcohol and Narcotics on Touch, Taste, and Smell. — Undoubtedly, these agents quite frequently lessen the sensitiveness of touch, taste, and smell. Tobacco smoke dries the nostrils, and by irritation of the tongue leads, in some cases, to a taste for alcoholics. Cocaine paralyzes the tactile sensibility of the tongue, and opium, by drying the tongue, interferes with taste.

QUESTIONS.

1. How are sensations valuable?
2. How may they be classified?
3. What is the effect of excessive stimulation of nerves?
4. What useful purpose has pain? Give examples.
5. What parts of the body are in general most sensitive?
6. Name sensations experienced through the nerves of the skin.
7. How many special senses are usually reckoned?
8. To what is the sensation of weight probably due?
9. What is necessary to a healthy exercise of all the senses?
10. Are the functions of the nerves of the special senses distinct from one another?
11. Can these senses be cultivated? How do we know this?
12. What are the objects of the sense of touch?
13. In what part of the body is touch most delicate?
14. What have you to say as to its capacity for varied application and training? Illustrate.
15. What are the organs of taste?
16. How is the mucous membrane of the tongue adapted to the exercise of this function?
17. Is there a distinct nerve of taste?
18. What takes the place of such a nerve?
19. Where is there the greatest sensibility to savors?
20. In what form must substances be to be tasted? Why?
21. What relation has this fact to the chewing of food?
22. Of what use is taste, in addition to its appetizing quality?
23. Do the other senses lend any intensity to the taste? Illustrate.
24. By what is the taste more or less influenced? Illustrate.

25. To what are morbid tastes sometimes due?
26. Give an instance of the capacity of the taste for delicate training.
27. How may the sense be blunted?
28. What is the essential organ of smell? Describe it.
29. How is the lower half of the mucous membrane of the nose supplied with ordinary sensibility?
30. In what form must odors be presented to be appreciated?
31. Illustrate the extreme sensitiveness of certain persons to odor.
32. Can the sense of smell be trained? Illustrate.

CHAPTER XVIII.

SIGHT.

356. Organs of Sight. — By means of *sight* we receive impressions of light, movement, form, size, shades of color, and the manifold beauties of nature and art. The organ of sight is the eye, and the parts belonging to the eye, or auxiliary to its use, are the eyeball, eyebrow, eyelids, eyelashes, lachrymal and Meibomian glands, tear passages, muscles, and optic nerve.

357. Eyebrows. — Each eyeball rests in an orbital cavity, partially surrounded by cushions of fat. The orbits are deep and conical, and are formed by the junction of various bones. Their upper front edges project and overhang their openings, thus forming the *brows*, which are covered with thick skin and short, strong hairs. The brows, with the other projecting walls of the orbits, and the nose, serve to protect the eyes from injury. The hairs of the eyebrows prevent the perspiration from flowing into the eyes.

358. Eyelids. — In front of each orbit are two movable curtains, known as the upper and lower *eyelids*, the upper being more movable than the lower. When closed, they cover the orbital openings. Both have upon their edges hairs (*eyelashes*) which project outward, the bulbs of which are supplied with nerves. The eyelashes are sensitive and give warning of the approach of insects, dust, etc.,

even in the dark; and, when the eyelids are partially closed, form an admirable screen. In some persons the eyelashes are long and silky, while in others they are short and stiff.[1]

A thin, loose skin covers the eyelids on the outside. Their inner lining is a thin mucous membrane, the *conjunctiva*, which also covers the front of the eyeballs. This membrane is extremely sensitive, and aids the eyelashes in protecting the eye from dust and other foreign particles.[2] Between the skin and conjunctiva of the lids are cartilages, which serve to preserve the convexity and firmness of the walls of the lids.

Embedded in the cartilages are the *Meibomian glands*, with their tubes. These glands secrete an oily material, which lubricates the edges of the lids, thereby preventing them from adhering and the tears from overflowing upon the cheeks.[3] The lids distribute the tear secretion over the surfaces of the eyes, assist in regulating the admission of

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[1] Sometimes, when the lids are diseased, the lashes turn inward and irritate the eye.

[2] *Conjunctivitis*, or inflammation of this membrane, is one of the commonest affections of the eyes, especially among those whose general health is deteriorated, or who are exposed to dusty or other irritating air. In Egypt, owing to the intense heat, to the high winds, and clouds of sand, this and other inflammations of the eye become very severe, even destroying the organ. It is said that many of the Crusaders in the Holy Land were made blind from these causes. Vitiated or devitalized air has a direct irritating effect on the conjunctiva, as on all mucous membranes. "This is shown by the fact that repeated attacks of inflammation of the mucous membrane of the eye, which have occurred in a vitiated atmosphere, and which have resisted all curative means, are often cured at once, and prevented from recurring, when a wholesome supply of air is obtained, all other conditions remaining the same."

[3] The last effect will be understood if the edges of a cup are greased and the cup is filled with water. The surface of the water may then be made higher than the edge of the cup, without the water's overflowing.

light, and protect the eyes from heat, cold, and the contact of foreign particles. The eye is closed by the action of a broad, thin, elliptical muscle which surrounds the orbit and spreads out upon the lids. By it the skin and soft parts about the eye are wrinkled and drawn together inward, and the lids held firmly together.

359. The Lachrymal Apparatus. — At the external and upper portion of the orbits are located the *lachrymal glands*, which secrete the *tears*. This watery secretion is constant, like the insensible perspiration. Part of it is carried into the nose through openings, one on the edge of each lid, near its inner extremity. These openings may be readily seen in a mirror by everting the lids. Each connects with two little canals (lachrymal canals, or tear ducts), which communicate also with an enlargement called the *lachrymal* or *tear sac*, and this latter with the *nasal duct*, which discharges into the nose (Fig. 103). The tear sac, together with the nasal duct, constitutes the *lachrymal canal*. The lachrymal secretion keeps the front of the eyeballs in that moist and transparent condition which is necessary for comfort and clear vision. If the eye becomes dry, as it does sometimes from disease or long exposure to dry, hot winds, it becomes clouded, and light does not easily penetrate it.[1]

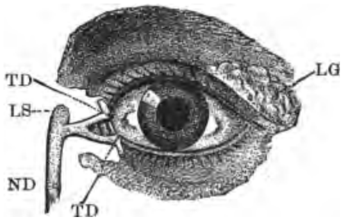

Fig. 103.

LG, lachrymal gland.
TD, openings of tear ducts.
LS, lachrymal sac.
ND, nasal duct.
Skin and parts external to these organs removed.

[1] Lustreless eyes are seen in fish which have been removed for a time from the water. In some forms of scrofulous or blood disease in the

Usually the lachrymal secretion passes into the nasal ducts after performing its functions; but, if largely increased in quantity by emotion or irritation, it overflows in tears upon the cheeks. Emotional persons may readily weep without adequate cause.[1]

360. Eyeballs. — Each eyeball is spheroidal in form, and has the segment of a smaller and more prominent sphere fitted upon its anterior portion, somewhat as a watch glass is set into its case (Fig. 105). The diameter of the eye from the front backward is about an inch; the transverse diameter a little less. The segment of the larger sphere, forming about five-sixths of the globe, is opaque, while that of the smaller and anterior sphere, the *cornea*, which is without blood-vessels, is transparent, light passing through it as through a clear window-glass.[2] The posterior five-sixths of each eyeball is composed of three coats, or tunics: the sclerotic,[3] choroid, and retina.

361. The Sclerotic Coat is a white, firm, fibrous envelope, not very sensitive, and having but few blood-

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human being, the Meibomian and lachrymal secretions are decreased in amount, and the eyes become bloodshot and cloudy, giving rise to the peculiar appearance known as "blear-eyed," the defect being enhanced by the roughening and falling out of the eyelashes.

[1] Sometimes, also, where the tissues of the lower lids are relaxed, as in old persons, and the lids are turned out, the tears overflow.

[2] The cornea is a modification of the sclerotic coat, its fibres being united by a cement-like substance into transparent sheets or membranes. It can be best seen by looking at it in the human being from the side, or by observing the reflection of objects upon it. In looking at an eye in front, we look through the cornea and aqueous humor.

[3] In childhood the sclerotic coat (Greek σκληρός, "hard") being thin, appears bluish, on account of the pigment behind. In old age it is yellowish, on account of deposit of fat.

vessels. It assists in maintaining the globular form of the eyeball, and protects the delicate structures within. To its outer surface are attached the six muscles, four straight and two oblique, which move the eye-ball. Upon the front of the eye the sclerotic coat forms what is called the "white of the eye," and is covered by the conjunctiva. In its inner surface are lodged the *ciliary nerves.* Behind, and a little to the inner side, it is pierced by the *optic nerve*, or nerve of sight, whose fibrous sheath is continuous with the dura mater of the brain. Along with and in the centre of its filaments there passes into the eye a large central artery, which is distributed to the lining coat.

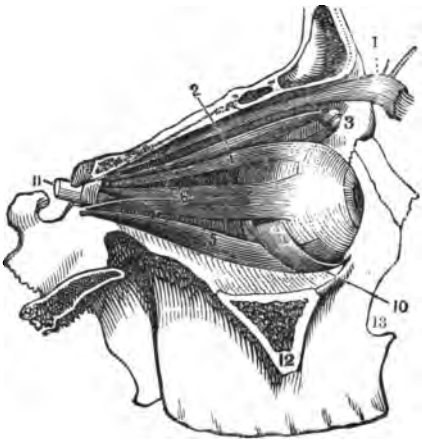

Fig. 104.

Muscles of the Eye.

1, the muscle which lifts the upper lid.
2, the superior oblique muscle.
8, the pulley through which its tendon plays.
4, 5, 6, superior, inferior, and external straight muscles.
10, inferior oblique muscle. 11, optic nerve.
12, cut surface of cheek bone. 18, nasal orifice.

362. The Choroid, sometimes called the *vascular coat*, is the middle coat of the eye, and is closely adherent to the inner surface of the sclerotic. It is soft, containing a network of blood-vessels, and is of a dark color, like the inside of the skin of a dark grape. It is lined with a layer of flat, dark-brown, or nearly black, pigment cells. This dark surface absorbs such of the rays of light enter-

ing the eye as would otherwise be reflected and diffused and prevent accurate vision.[1] In albinos, the pigment cells are deficient, and accordingly vision is imperfect when the eyes are exposed to strong light.

363. The Iris and Pupil.—A prolongation of the choroid coat in the front of the eye forms the *iris*, which is a curtain across the interior of the eye, behind the cornea, to the margin of which it is attached. In its centre is the *pupil*, a round opening, through which must pass all the light that enters the eye.[2] The iris is a muscular organ having two sets of fibres, one circular and one radiating. Through the involuntary action of these fibres the pupil contracts or dilates, when exposed to greater or less light, thus performing its function of regulating the amount of light admitted to the retina. But the pupil does not act instantaneously; hence, on coming into a bright light from a dark room, or going into a dark room from the

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[1] Optical instruments, microscopes, opera glasses, and telescopes are black on their inner surface, for the same reason. The inside of the photographic camera is also black, that the light admitted may be concentrated and the picture properly produced on its sensitive plate, which might be called the retina.

[2] The shape of the pupil differs in different animals. In the cat it is a narrow, horizontal slit when contracted, and is round when dilated. Capable of great dilatation, it enables the cat to see even in the dark. In the human eye the pupil seems black, except in the case of the albino. The black appearance is due to the fact that, in looking at the pupil, we look into a dark chamber at the back. In the albino, the pigment cells being deficient, we see the pinkish color afforded by the blood-vessels. In certain nocturnal animals, such as wolves and cats, in obscure light the pupil presents a sparkling or glaring appearance, which at one time was supposed to be due to a kind of phosphorescence, but is now recognized as a reflection from a patch of metallic lustre found upon the choroid coat of the eyes of these animals.

bright sunlight, vision is confused until the proper amount of light has been excluded or admitted by the contraction or expansion of the pupil, and until the retina also has accommodated itself to the change. Cer-

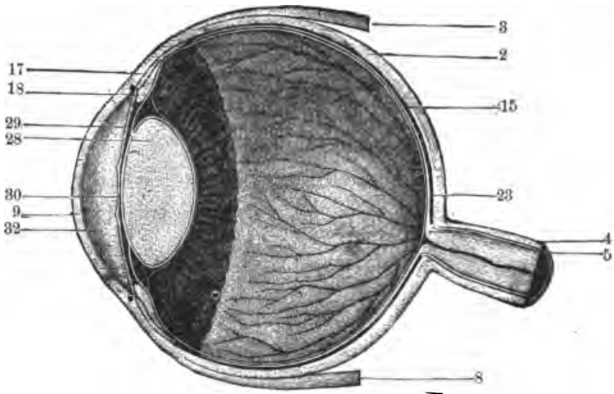

Fig. 105.

Vertical Section of the Eyeball, and Part of the Optic Nerve.

2, sclerotic coat.
4 and 5, external and internal coverings of the optic nerve, continuous with those of the sclerotic coat.
8, superior and inferior straight muscles.
9, the cornea.
15, the choroid coat.
17, ciliary muscle.
18, ciliary body.
23, branches of central artery of the retina.
28, the crystalline lens.
29, the iris.
30, the pupil.
32, anterior chamber.

tain medicinal substances have the property of dilating, and others of contracting, the pupil. For example, belladonna (or atropine, which is its active principle), taken internally or applied to or about the eye, dilates the pupil, while opium and the calabar-bean contract it.[1]

[1] The acts of dilatation and contraction of the pupil may be seen by alternately covering and uncovering the eye of another, with the hand, for a moment. In many young persons considerable dilatation is normal, while the same is true of contraction in some old persons. *Extreme*

The color of the iris varies, and is apt to be in accord with the general coloring of the individual.[1] By the terms, blue, brown, hazel, gray, or black eyes, the color of the iris is indicated.[2] Just behind the iris, toward its circumference, lie the *ciliary muscle* and the *ciliary body*. The latter is a dark pigmented mass, arranged in fluted folds known as the ciliary processes (Fig. 105).

364. The Retina is the third coat, and lines nearly the whole of the posterior portion of the eyeball.[3] It is a delicate, transparent membrane, containing an expansion of the filaments of the optic nerve. It is the only part of the eye that is directly sensitive to light. But sometimes a jar of the retina or optic nerve by a blow upon the head, or an electric shock communicated to the eyeball, or any irritation applied to the retina, produces flashes of light,—an effect which is familiarly termed "seeing stars." The function of the retina is to receive the rays of light which enter the pupil of the eye, and communicate the impressions thus produced through the optic nerve to a visual centre of the cerebrum.

The retina is not equally sensitive to light throughout its whole extent. The point of entrance of the optic

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contraction or dilatation of the pupil is the result of poisoning or of disease.

[1] Sometimes brunettes are seen with light eyes, and blondes with dark ones, and occasionally a person is found with one eye light and the other dark.

[2] The eyes of young infants are almost always blue, the color not beginning to change until the sixth or eighth week of life.

[3] Its greatest thickness is said to be not more than $\frac{1}{120}$ of an inch, and microscopists describe eight or ten different layers in it. An outer one contains the "rods" and "cones," which are most intimately concerned in the perception of light, while next to the inner coat is the expansion of the optic nerve.

nerve is insensible to light, and is therefore called the "blind spot."[1] About one-tenth of an inch outward from this point in each eye is an oval, called the "yellow spot," which is the most sensitive part of the retina. This spot is directly in the line of distinct vision.[2]

Each impression received by the retina lasts for a time before fading away. If impressions are received too rapidly one after another, vision is confused or dazzled, or the objects seem to be one; the old impressions are retained while the new ones are being received. Thus, the spokes of a rapidly revolving wheel seem to form a continuous disk. A lighted torch rapidly swung around shows a circle of light. Two colors upon a card, if rotated rapidly, are confused into a blurred image, or, if the colors are primary, the complementary secondary color is perceived.[3]

The retina becomes tired and loses its sensibility by looking for a long time steadily at one object, and the

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[1] The blind spot may be found by a simple experiment. Place the two thumbs side by side about twelve inches from the face. Shut the left eye, and look at the left thumb *intently* with the right eye, while you gradually move the right thumb away from it toward the right. At a certain point, generally about six or seven inches, the right thumb will seem to disappear. If carried still farther away, it will be again seen. The explanation of this phenomenon is that, at the point of disappearance, the picture of the thumb falls upon the blind spot.

[2] The yellow spot, upon which the rays of light converge, *i.e.* are focussed, receives impressions through the motions of the eyeball from side to side as in reading, or in various directions, as we catch at a glance the beauties of a landscape.

[3] Toys for children, in which figures seem actually to be in motion, are constructed on the principle stated above. The biograph camera takes pictures at the rate of forty per second. In exhibitions these are reproduced on a screen, from films 150 to 300 feet long, which travel in front of the camera lens at the rate of about five feet per second.

sight is relieved by closing the eyes for a moment, or by an occasional glance at other objects.[1]

365. Transparent Media of the Eyeball. — In addition to the cornea in front of each eyeball, within it there are three other transparent media, the aqueous humor, the vitreous humor, and the crystalline lens. The vitreous humor is a colorless, transparent, jelly-like substance, inclosed within the retina. It assists in preserving the form of the eyeball, and affords support to the delicate retina. On its front, in a cup-like hollow, rests the crystalline lens. Between the lens and the cornea is the aqueous humor, consisting of a small quantity of watery fluid, which enables the iris to move freely.

366. The Crystalline Lens is located just behind the iris and in front of the vitreous humor. It is about one-quarter of an inch in thickness, and is shaped like a double convex lens or magnifying glass. It is contained in a capsule, kept in place by a suspensory ligament, which is a continuation of the inclosing membrane of the vitreous humor.[2] The lens is of the consistency of jelly, but very elastic, especially in children; consequently, in them the shape is very readily changed, while in old persons the lens, being quite hard, is not easily changed.

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[1] Looking steadily for a time at a bright light or spot will cause it to appear dark. After resting the eye, this dark color disappears.

[2] Cataract is an opacity of the crystalline lens, and not a "white spot on the front of the eye," as some believe. It may affect the whole or a part of the lens. Usually light is transmitted through the lens when so affected, as through a ground glass window. To restore transparent media, or to remove the irritation which such opacity may set up, the lens may be removed by operation. Vision can then be restored in part by the use of spectacles or eyeglasses, *i.e.* artificial lenses.

The function of the crystalline lens is to assist in bringing rays of light to a point or focus upon the retina. This is necessary to distinct vision; for without the lens, the rays would not come to a focus, and sight would be blurred. At the focal point, an inverted image of the objects from which the rays proceed is pictured upon the retina.[1] Notwithstanding this inversion, in normal vision these images are seen in their proper positions and relations, because we have learned, by comparison and experience, to appreciate the size and form of objects reflected upon the retina. Since the brain is the ultimate organ of perception, a disordered brain will sometimes perceive distorted images of objects of which the retina receives correct impressions. So, too, apparent vision is possible without any retinal impression at all, the disordered brain seeing some phantom image of its own creation. In this way, in dreams objects appear to be so vividly seen that they may be readily described when the sleeper awakes.

367. The Optic Nerve, which carries impressions from the retina to the cerebrum, is inserted into the posterior segment of the eyeball, a little to the inner side of its centre. Passing into the cavity of the skull, the nerves from the eyeballs approach each other till they consolidate, forming what is known as the *optic chiasm*. At

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[1] So, in a bright, direct light, by means of a convex lens, objects, such as trees and drawings, may be pictured upon a white or light-colored surface, but always inverted or upside down. A candle flame held before the cornea of an eyeball removed from a bullock (the sclerotic and choroid coats at the back of the eyeball being detached) will be seen reflected inverted upon the retina. When the lens has been removed from the eye by operation, the focus of the rays of light falls about three-eighths of an inch behind the retina, and the object seems much larger than it really is, and much less distinct.

this point there occurs a *crossing of a portion of the optic nerve fibres*, so that some of the filaments pass from the left optic nerve to the right, and from the left eyeball to the right eyeball, and *vice versa*. Filaments also pass from one optic tubercle, that is, from the origin of one optic nerve, to the other.[1] The eyes, as Dalton remarks, "are not so much two distinct organs, as one double one." Besides the direct impressions (color, size, etc.) carried to the brain by the optic nerves, impressions which result in reflex action are brought back to the eye from the optic tubercles. A stimulus of light, for example, is conveyed to the optic tubercles, and is reflected outward to the muscular fibres of the iris, causing contraction or dilation, as the case may be.

368. Binocular Vision. — Objects are ordinarily perceived by the simultaneous use of both eyes, *i.e.* by *binocular vision.* Two images of each object are formed at the same time, one upon each retina, though so combined as to produce the impression of but one object upon the brain.[2] With binocular vision we appreciate, with greater accuracy, the solidity and distance of objects; hence, with one eye closed, the difficulty of threading a needle, or touching any object quickly, will be much increased (*a*).

369. Power of Accommodation, or Focussing. — All the various directions from which rays of light come into

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[1] The optic tubercles are cerebral ganglia on the under surface of the brain, near its front portion, in which the optic nerves originate.

[2] The best binocular vision results when the images are both upon the yellow spots. If this be not the case, if, for example, one eye be pressed a little to one side by the finger, and an object is then looked at with both eyes, the object will seem double, the images falling upon different points in the two eyes.

the pupil, taken together, form what is known as the *field of vision.* Objects can be most distinctly seen in the centre of this field. To enable one to have a long or short range of vision at will, to see remote objects, and then, within an incredibly short time, those close at hand, the crystalline lens, especially, has a *power of accommodation.* This power also resides in the cornea, iris, and probably in the humors of the eye, but in a minor degree.

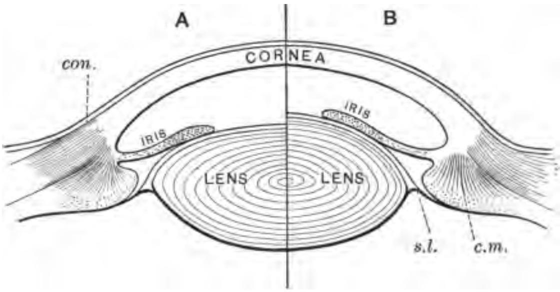

Fig. 106 (FOSTER AND SHORE).

The Changes in the Lens in Accommodation. — A, adjusted for distant objects. B, adjusted for near objects. *con.*, conjunctiva. *c.m.*, ciliary muscle. *s.l.*, suspensory ligament.

Objects at different distances cannot be plainly perceived at the same time. The lens in each case must be accommodated to the distance.[1] Thus, while we gaze at

[1] "There are two ways in which this adjustment might be effected. The length of the eye might be varied to meet the varying distance of the focal point, just as a photographer moves the sensitive plate of his camera backward or forward to bring it into focus. But, as a matter of fact, another process takes place in the eye. The retina is not moved backward or forward, but the refractive power of the crystalline lens is changed by an alteration of its thickness. Now, when we look at distant objects, and no effort of accommodation is required, the anterior surface of the lens is kept flattened by the pressure of its capsule, and by the elastic pull upon it of the anterior suspensory ligament, — an elastic pull

a fly upon a window-pane or the threads of a veil, we do not see plainly the landscape beyond. If we see the landscape plainly, the fly or the threads of the veil become indistinct. This accommodation is the result of changes in the shape of the lens, produced by the ciliary muscle, which encircles the lens and is connected with the delicate ligament that holds the lens in position. As the objects looked at are brought near the eye, the lens becomes more and more convex. When the eye is at rest, or when objects are distant, the lens is more flattened. The ciliary muscle bears the same relation to the eye as the adjusting screw does to the opera-glass, the photographer's camera, or the microscope.

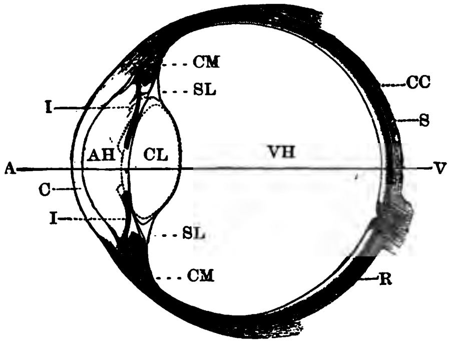

Fig. 107.

Section of Eye.

The line A–V is the axis of vision. The dotted lines show the position of the iris and the shape of the lens in accommodation for a certain distance.

S, sclerotic coat.	AH, aqueous humor.
C, the cornea.	CL, crystalline lens.
CC, choroid coat.	I, the iris.
R, retina.	CM, ciliary muscle.
VH, vitreous humor.	SL, suspensory ligament of lens.

The range of accommodation is limited, and differs in different individuals. Ordinarily, accommodation fails

which involves no muscular strain, and consequently no fatigue. But when we wish to look at a near object, the ciliary muscle, contracting, pulls forward the suspensory ligament and diminishes its circle of attachment, its tension is lessened, the pull on the capsule of the lens diminishes, and the lens, by its own elasticity, assumes a more spherical shape, its anterior surface moving forward and its power of converging rays being increased." — *Physiology of the Senses.*

and vision is imperfect, when the object is less than six inches from the eye. Vision becomes imperfect and blurred, outside or inside of each one's normal limit. The average eye is able to recognize type one-thirty-second of an inch in height, held at least eighteen inches off,[1] and type three-eighths of an inch in height twenty feet away. But the ability to see plainly objects, either at a distance or near the eyes, can be developed by training.[2] The pilot clearly defines objects at a long distance, even in an obscure light, which the average eye could not even distinguish. On the other hand, the watch-maker's eye-sight is very acute for objects near at hand.[3]

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[1] "The following paragraph from Dr. Snellen, of Utrecht, the author of the test-types in general use, gives a specimen of letters one-thirty-second of an inch in height: —

"We have adopted as proper objects square letters, the limbs of which have a diameter equal to one-fifth of the letters' height. Such letters are clearly distinguished by a normal eye at an angle of five minutes. As the limbs and subdivisions of the letter just measure one-fifth of their height, they present themselves at an angle of one minute; for instance, our letter C shows an opening, as compared with the O, of one minute visual angle. In testing accuracy of vision, we accept perfect recognition, and not uncertain perception, of the letters."

[2] This training is in reality more that of the brain than of the eye. Acute vision is therefore sometimes called "brain-sight."

[3] The eyesight may be brought to a high state of perfection by proper cultivation. It is related of Professor Agassiz that he once selected as an assistant the candidate who could best see and *describe* what was to be seen from an open window. One person saw merely a board fence and a brick pavement, another added a stream of soapy water, while a third detected the color of the paint on the fence, noted a green mold or fungus on the bricks, evidence of bluing in the water, and other details. Houdin, the celebrated prestidigitateur, in his autobiography, attributes his success mainly to the quickness of perception which he acquired by walking repeatedly and rapidly by a shop window full of miscellaneous articles, endeavoring to recognize as many objects as he could at a glance. In many respects the human eye resembles the photographic camera, with its darkened chamber, reflecting surfaces, adjusting screws, sensitive plates, etc. When used by an experienced and painstaking owner, much more accurate pictures are produced than if the owners are reckless or uneducated.

370. Physiology of Vision. — Rays of light traverse the transparent and refracting media of the eye and fall upon the retina, picturing upon it images looked at. The impressions brought to the retina stimulate the activity of the fibres of the optic nerve, and are transmitted by them to the cerebrum. The visual nerve centres, in which the optic nerve fibres originate, thus stimulated, produce the sensation of light and objects, and we see.

371. Defects in Vision. — Owing to the extreme sensitiveness of the eyes, *defects in vision* are quite common. In cases of injury to or disease of one eye, the peculiar crossing of the fibres of the optic nerves may give rise to sympathetic inflammation, or disease of the other eye.[1]

The ophthalmoscope, an optical instrument which, used in a dark room, by means of reflected light, illuminates the bottom of the eye, was invented by Helmholtz in 1851. It enables the physician to detect optical defects which the patient may not have been aware of. Before the use of the ophthalmoscope, many diseased or disordered conditions of the eye were not accurately recognized. For example, it was not known that defective circulation in the retinal blood-vessels may disturb the vision; nor that changes in the form, consistency, or relation of the various parts of the eye may induce grave optical defects.

372. Color Blindness is the inability to distinguish certain colors. Helmholtz and others consider red, green, and violet as base colors, *i.e.* colors by the mingling of which, in proper proportions, white and the various colors of the solar spectrum may be produced. It is believed

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[1] As to the removal of foreign bodies, and the treatment of injuries of the eye, see Emergencies, page 400.

that there are special retinal elements for the perception of each of these base colors, and that the color-blind are deficient in one set of these elements, most commonly the red.[1] It is especially important that railroad employees and seamen should not be color-blind. Vessels carry at night upon their right hand or starboard side a green light, and upon the left hand or port side a red light. A red light is also the danger signal upon railroads. Color-blind engineers may not distinguish danger signals, nor color-blind pilots know how to pass an approaching vessel, thereby causing collision and loss of life. Especially are accidents to be expected, if the atmosphere is so humid that these men cannot distinguish the difference in the luminosity as well as in the color of signals (*a*).

373. Short, or Near, Sight. — An eye perfectly formed, *i.e.* one in which rays of light are made to focus directly upon the retina, is called an *emmetropic*[2] eye. If the axis

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[1] Color-blindness in general is called Daltonism, from Dalton, the English chemist, who first carefully described it, and was himself subject to it. It is related that his friends were much concerned when he was to be presented at court, for fear that, being a Quaker, he would not wear the scarlet robe which his position required him to wear; but to him it seemed of a gray color. "It is said that Dalton was twenty-six years old before he knew he was color-blind. He matched samples of red, pink, orange, and brown silks with green of different shades; blue both with pink and with violet; lilac with gray." "The common form of defective color vision is *red-green* blindness, of which there are two varieties — the *red-blind* and the *green-blind.* In each variety there are many gradations of sensibility."

[2] From the Greek word ἔμμητρος, *i.e.* "normal." Accuracy of vision may be ascertained by employing the ordinary cards used by ophthalmic surgeons, upon which are printed Roman letters of different sizes. Each line of letters has at the end a number, which denotes the distance in feet at which a person should stand and see the letters clearly. If he can do this, he possesses normal acuteness of vision. According to the

of the eyeball is too long or too short, the focus will not fall upon the retina, but in front of or behind it. There is then said to be an error of refraction. In *myopia*,[1] or short sight, the axis of the eye is too long, and rays of light entering the eye are focussed in front of the retina. Objects are not plainly seen until they are brought near

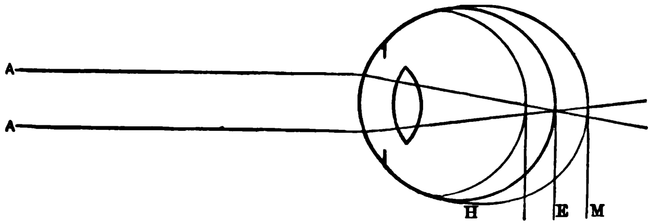

Fig. 108.

A, parallel rays of light. E, emmetropic or normal eye, rays focussing at proper point.
H, long-sighted eye. M, short-sighted eye.

enough for their images to be focussed upon the retina. This condition is often hereditary, but is also induced by strain,—for example, by reading very small print in a poor light, or by long, uninterrupted use of the eyes in close work. For its relief, properly fitted concave glasses are needed (*a*).

374. Long, or Far, Sight.—In *hypermetropia*, or long sight, the axis of the eyeball is too short, and the focus falls beyond the retina. The performance of accommoda-

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usual system employed in eye infirmaries, if a certain line is to be read at a distance of twenty feet, and the pupil can do so, he is marked $\frac{20}{20}$; if he must go closer, and can first distinguish at eleven feet, he is marked $\frac{11}{20}$, the denominator of the fraction representing the normal distance, and the numerator the actual distance.

[1] So called from Greek words which mean "to close the eyes," since short-sighted persons often partially close the lids in order to see distinctly, by shutting off the rays of light that do not come to a proper focus.

tion is painful, even when there is no attempt to use the eyes in near work. Print becomes blurred and misty if reading is continued too long. In children there is always danger of squint resulting from the effort to see things close at hand. This condition can be relieved by convex glasses, which will converge the rays of light upon the retina.

375. Old Sight. — *Presbyopia*, or old sight, is a failure of accommodation, *i.e.* a loss of power to adjust the focus of the eye for near objects. It is especially due to the fact that with increasing age the lens becomes stiffer, and incapable of being bent into the convexity necessary for the adjustment of the focus for near objects.[1] To remedy this defect convex lenses are required.

376. Astigmatism. — Another optical defect is *astigmatism*, or the inability of the eye to focus, at the same time, lines perpendicular to each other (Fig. 109). This condition depends upon a difference in the curvature of the different meridians of the cornea or lens. Persons so affected may readily distinguish horizontal or perpendicular lines of type, but not both sets equally well at the same time.

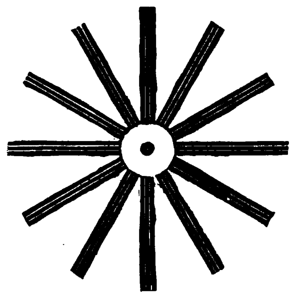

Fig. 109.

[1] Sometimes old people are delighted at the return of what is called "second sight," by which they are enabled to read without the aid of their accustomed glasses. In fact, they have become short-sighted, owing to a change in the shape of the lens, and can see clearly objects near at hand, while objects far off are more indistinct than before.

377. Effects of Alcohol and Tobacco upon Sight. — In some persons, alcohol in excess produces a troublesome conjunctivitis, and occasionally defective vision due to changes in the retina, optic nerves, or lens. Temporary color-blindness, and a form of defective sight known as "tobacco blindness," due to some changes in the optic nerves not fully understood, often result from the intemperate use of tobacco. These conditions are likely to be chronic if the use of tobacco is continued.

378. Hygiene of the Eyes. — Proper care of the eyes is of the greatest importance. Healthy and well-formed eyes, if properly used, do their work without the consciousness of their owners. Pain or discomfort in the eyes, or even slight defects in vision, are warnings of disorder, if not of disease. But persons whose general health is unusually good are likely to be overconfident, and so fail to take notice of these warnings in time. Young children are too frequently encouraged in persistent near work, such as drawing, studying, reading, and sewing. Such children may become prodigies, but the soundness of their eyes is frequently sacrificed (*a*). Most of the eye troubles of infants are the result of the careless exposure of their sensitive eyes to glaring light or to impure air, or of the application of poultices and other materials to the eye. In adult life certain occupations tend to weaken the eyes, but even in such cases much can be done to save them. The following directions for this purpose are those deemed most important: —

1. For all kinds of work have an abundance of clear and steady light, especially when engaged in writing, reading, embroidering, painting, or other work which tries the eyes. Fine work and that upon dark surfaces should be

performed by daylight. Using the eyes closely during twilight is injurious.

2. Avoid a glaring light, and see to it that the sun does not shine directly upon your work. Interpose shades of ground glass, or light blue or gray tinted glass or paper. The reflection into the eyes of sunlight from the surface of mirrors is not to be tolerated.

3. Let the light reach your work preferably from the left side and from above, not from in front.[1]

4. When using artificial light (*i.e.* that from a lamp, gas, etc.), it is beneficial to shade the eyes from any heat and glare. If gas is used, the Argand burner, or the Welsbach, with its shade and chimney, is advisable. If a lamp, use only the best oil and a good lamp. "A slight tinge of blue or gray in the shade or chimney modifies the light pleasantly by absorbing the excess of yellow rays."[2] The heat and glare of bright illuminating rays may be lessened by the interposition of globes filled with water.

5. When reading, it is important that the type should be clear, of good size, and printed in dark, not pale, ink; that the *paper* printed upon should have a yellowish tinge, or not be absolutely white.[3] For sensitive eyes, ink with a bluish tinge may be preferable (*b*).

6. Do not read or write when walking, lying down, or riding, for under these conditions the accommodative

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[1] If from the right or from behind, shadows are cast upon the work.

[2] Lamps, such as the Rochester, with a centre draught, give a stronger and steadier light than common lamps, and are therefore better. The incandescent system of gas lighting (Welsbach) is superior to ordinary gas light. The incandescent electric light is also good, but bright gas and electric light should be tempered by light blue, gray, or green shades.

[3] Most oculists believe that the best paper is that which is known to the trade as "natural," *i.e.* which has no dye in it, and which has been bleached but little and is not glazed.

apparatus of the eyes is strained. Especially is this true if we read in moving vehicles, for the irregular muscular strain resulting is exhausting to most eyes. Reading during convalescence from debilitating illness is attended by an improper strain of the weakened eye muscles.

7. Do not bend over your work for any length of time; such a constrained position tires the muscles of the eye, as well as those of the neck and trunk.

8. Prolonged and uninterrupted tension of the eyes over any kind of work is injurious, but especially is this true of fine work. Look up and away from the work frequently, directing the sight toward varied and distant objects.[1] Rest the eyes, if they are fatigued or painful, or the images produced are blurred.

9. In reading, a book should not be held nearer to the eyes than is necessary to see the print distinctly. Print like that in the text of this book should not be read continuously nearer than about eighteen inches. If you are obliged to hold it nearer than fifteen inches, the probability is that you are near-sighted; if two feet away, far-sighted.

10. If the eyes ache or are weak, bathe them frequently in clear hot water, but do not use eye-washes, soap, poultices, or other application, unless prescribed by a physician. The eye is too precious an organ to be trifled with.

11. "Have all diseases of the eye treated early and skilfully, and remember that the well eye sympathizes with the diseased one, and you may lose both unless early atten-

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[1] Writing tables and desks covered with blue or green cloth, paper, or leather, serve to rest the eyes. Rooms papered and painted in the same colors have the same effect. It is a disadvantage of city life that the eyes are occupied for the most part with close objects. Excursions into the country are valuable partly for the rest afforded the eyes.

tion is given to the matter. Diseases of the eyes in which a large amount of matter forms are dangerous, and patients so affected should be careful to get no matter from the diseased eye into the well one, and they should have a separate basin and towels for washing purposes."

12. If you need to wear glasses or spectacles, do it; the eyesight is more important than personal appearance.[1]

13. Beware of quack eye-doctors, and travelling or street venders of spectacles; they lack medical education and experience. Even plain colored glasses or goggles, used without proper advice, are likely to be injurious.

QUESTIONS.

1. What are the parts belonging to the eye, or auxiliary to its use?
2. Describe how the eyes are protected from injury by situation; by the eyebrows; by the eyelids; and by the eyelashes.
3. What is the conjunctiva and its function?
4. Of what use are the cartilages of the lids? the Meibomian glands?
5. What are the functions of the eyelids?
6. By what are tears secreted, and how are they disposed of?
7. Of what use are the tears, and how is their secretion increased?
8. Describe the eyeballs.
9. How does light enter them, and through what media?
10. How many and what coats has the other, or opaque, part?
11. Describe the sclerotic coat, and tell how the eyeball is moved.
12. What gains admission to the eye through the sclerotic coat, and where?
13. Locate, describe, and give the use of the choroid coat.
14. Of the iris and pupil.

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[1] The eyes may be protected from glare of light, such as the reflection from snow or sand, by smoked or light blue glasses; from great heat, as in furnace rooms and smelting works, by the use of mica, instead of glass. People exploding fireworks find eye protectors of asbestos valuable.

15. To what is the color of the eye due?
16. Where is the ciliary muscle?
17. Locate, describe, and give the functions of the retina.
18. Explain what is meant by the "blind spot"; by the "yellow spot."
19. Why do the spokes of a rapidly revolving wheel seem to run together?
20. How may the retina of the eye become tired and cease to act? and how may its action be restored?
21. Locate, describe, and give the use of the vitreous humor; of the crystalline lens.
22. In what position are the images of objects thrown upon the retina? Why do we see them in their proper position?
23. What is the ultimate organ of perception, and to what are unusual visions due?
24. Where and what is the aqueous humor?
25. What is meant by the "field of vision"?
26. What by the "power of accommodation," and to what is it due?
27. Give illustrations of the effect of training the power of accommodation.
28. What is the object of the optic nerves?
29. At what point does a decussation of the optic nerves take place?
30. How is the iris stimulated to contract and dilate?
31. What is meant by binocular vision, and what is its use?
32. What is meant by an emmetropic eye?
33. What is myopia, and to what is it due?
34. What bad habits produce it, and how can it be relieved?
35. What is hypermetropia, and to what is it due?
36. What is presbyopia, and to what is it due?
37. How are hypermetropia and presbyopia remedied?
38. What is astigmatism, and to what is it due?
39. What is color-blindness and what are its dangers?
40. What cautions must be observed in the care of the eyes?

CHAPTER XIX.

HEARING.

379. Sound. — *Hearing* is effected by means of impressions made by the vibration of elastic bodies (ordinarily the atmosphere) upon the organs of hearing.[1] A shock from a sounding body, communicated to the surrounding atmosphere, passes in waves toward the ear, moving like the ripples upon water after a pebble has been thrown into it.

When the vibrations follow each other regularly, *musical sounds* are produced; when they are irregular, *noises* result. The *pitch* of sounds depends upon the rapidity of the vibrations. Their *intensity*, or *loudness*, depends upon the amplitude of the vibrations. "Thus a tuning-fork bowed gently will give out a faint sound, while the same fork bowed strongly will give a note of the same pitch as the former, but sounding much louder." There is also a property of sound called *quality*,[2] which enables us to distinguish, for example, the piano from the violin, or a musical instrument from the human voice. Most vibrating bodies give out complex sounds, made up of a vibration as a whole, known as the "fundamental tone,"

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[1] The earth, wood, and many other solid substances transmit sound readily. Even so slight a sound as the scratching of a pin on one end of a long log may be heard at the other end. An approaching train may be discovered by the sound transmitted through the iron rails.

[2] In musical sounds this is known as "color," "timbre," or "klang."

and of partial vibrations, *i.e.* "partial tones," or "over tones."[1] We distinguish one instrument from another, and one voice from another, by the number and comparative strength of these partial tones. The notes on the piano and organ are said to vary from 33 to 4224 vibrations in a second. The piccolo emits a shrill note of 4752 vibrations in a second. These are the ordinary notes used in music, but the human ear can distinguish a note with as few vibrations as 20, or as many as 38,000, in a second. The higher tones, however, are more or less painful to the ear, so powerful are the vibrations in the air of the auditory canal.

380. The Organ of Hearing is the *ear*. It has a very complex and delicate structure, which is for the most part located in the petrous, or stony, portion of the temporal bone, and is thus well protected from injury. It is divided into three parts,—viz., the *external*, *middle*, and *internal* ear. The first two are for the collection and transmission of sounds; the last, for their reception and conveyance to the brain, through the auditory nerves, which connect with it.

381. The External Ear includes the *auricle*, commonly called the ear, and the *auditory canal*, which leads to the *membrana tympani*, or *drum-head*. The auricle is a shell of cartilage covered with skin which closely fits its every groove, ridge, and depression. It flares out something like a funnel, the better to catch vibrations of sound.

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[1] Every sound is composed of a number of partial tones, just as light is composed of a number of colors. Partial tones are also called "harmonics."

In man it is rarely movable, the muscles for that purpose not being large or well developed.[1] It is well supplied

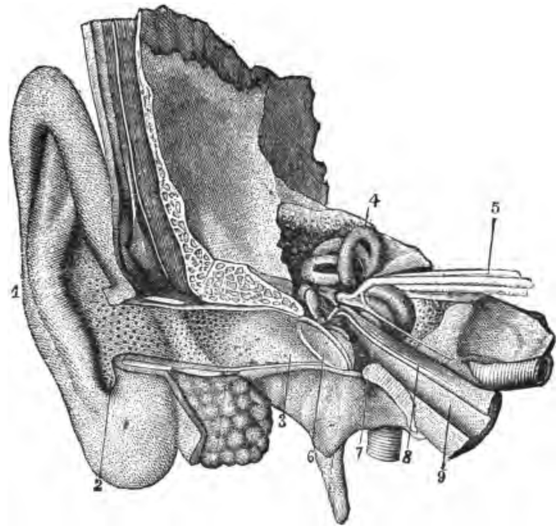

Fig. 110.

The Organs of Hearing.

1, auricle.
2, opening of ear, showing orifices of sebaceous glands.
3, external auditory canal.
4, semi-circular canals.
5, auditory nerve, with facial nerve.
6, membrana tympani, with the elastic fibrous membrane which forms its border.
7, tympanic cavity.
8, tensor muscle of the tympanum, the tendon being attached to the upper portion of the handle of the malleus.
9, upper portion of Eustachian tube.

with blood-vessels, nerves, and lymphatics, and has at its lowest part a cushion of fat and fibrous tissue.[2]

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[1] In animals the auricle is generally very movable, enabling them to perceive faint sounds by turning the ear toward them. Even some human beings possess considerable power in this respect.

[2] Sometimes the cartilage dips down into the lobule, and is liable to injury when the ear is pierced for ear-rings. Serious inflammation may thus be produced.

The auricle gradually blends with the walls of the auditory canal. This canal is about one and one-fourth inches long, averages one-fourth inch in diameter, and has first an upward, then a downward, inward, and somewhat forward direction. The outer one-third is cartilage; the inner two-thirds, bone. Through this canal the drum-head, which closes its lower end, may be seen by means of a reflecting mirror and an instrument called the *ear speculum.* The walls of this canal are lined with skin, which is continuous with that of the auricle, and also with that over the drum-head, where the skin is very fine. In the auditory canal are an abundance of both sweat and sebaceous glands, and many coarse, stiff hairs. It has also numerous wax-producing glands,[1] which secrete the wax of the ear, a sticky and bitter substance that tends to prevent the inroads of insects and the growth of fungi.

382. The Drum-head, or *membrana tympani* (wrongly called *the drum*), at the bottom of the auditory canal, is the partition between the external ear and the middle ear, or drum cavity. It is circular in form, about one-fourth of an inch in diameter and $\frac{1}{250}$ of an inch thick, and consists of three layers: an outer one of skin, a middle one of fibrous tissue (to which the other layers are attached), and an inner one of mucous membrane, continuous with the lining membrane of the drum cavity. The external surface of the drum-head is smooth and of a pearly lustre. Near its central line is an opaque, white ridge, due to the attachment of the so-called handle of the hammer, one of the small bones of the ear, to the middle layer of the drum-head.

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[1] They are classified as modified sweat glands.

383. The Middle Ear, tympanum, or drum proper, is an air cavity,[1] about one-half inch in height and width, and about one-fourth of an inch deep. It is lined with mucous membrane, a continuation from that of the throat, through the Eustachian tube, which tube connects the drum cavity with the pharynx. Connected with this cavity from behind, and lined with mucous membrane, are the mastoid cells, or little air cavities in the mastoid portion of the temporal bone[2] (the prominence immediately behind the auricle). Through these cells, or through the roof of the drum cavity, which is very thin, an inflammation of the middle ear may extend to the brain.

384. The most important contents of the drum cavity are the three *ossicles*, or little bones of the ear; viz., the *malleus* or hammer, the *incus* or anvil, and the *stapes* or stirrup, so named from a resemblance to these objects. Though weighing but a few grains, these little bones have muscles, cartilages, and blood-vessels, and are so joined together that they form a bridge, or chain of bones, reaching across the drum cavity from the drum-head to the internal ear. By vibratory motions they *convey sounds to the fluid of the internal ear*, in which float filaments of the auditory nerve. The bone nearest the drum-head, and the largest of the three, is the hammer, which is held in position by ligaments attached to the roof and outer wall of the drum cavity. Its handle is, as we have seen,

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[1] This cavity, or drum, in its construction, somewhat resembles an ordinary snare, or military, drum, which is a reservoir of air, with two drum-heads capable of vibration. In an ordinary drum, air is admitted to the inside (drum cavity) by holes in the sides of the drum. Into the drum of the ear, the air is admitted through the Eustachian tube.

[2] Supposed to be concerned in the resonance of the voice.

fastened securely to the middle layer of the drum-head, while its head is articulated with the next bone, the anvil. The anvil is held in position by two ligaments, one attached to the upper and posterior wall of the drum cavity, and the other to the drum-head. If the handle of the hammer is pulled outward, this joint between the hammer and anvil unlocks, releasing the anvil, but if it is pushed inward, the anvil is carried with it. The anvil is joined to the stirrup, its long process, or leg, fitting into a depression in the head of the latter. The foot-rest of the stirrup is oval, and accurately fits into the oval window of the *labyrinth*, as the cavity of the internal ear is called.

385. The Eustachian Tube is a little more than an inch and a half long, and its direction from the mouth to the ear is upward, outward, and backward. In the act of swallowing, the anterior wall is pulled away from the posterior by muscle fibres, offshoots from the muscles of the palate, and air enters the Eustachian tube.[1] Attached to the drum-head is a delicate prolongation of one of these offshoots, known as the *tensor tympani*, or stretcher of the drum. This tube supplies air to the drum cavity, forms an escape tube for its secretions, and is a passage for equalizing a counter current of air, when the drum-head is driven suddenly in by the concussion of a blow or explosion. Gunners, when a heavy cannon is about to be fired, open their mouths so that the force of

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[1] Repeated acts of swallowing are said to prevent much of the discomfort and pain in the ears consequent upon going down in diving-bells and ascending mountains.

"The advantage of having the tube closed at all times, except when we swallow, lies in this, that were it always open there would be too much reverberation caused in our ears by the sound of our voice."

the concussion may be less felt.[1] Closure of the Eustachian tube is apt to cause deafness, by preventing free entrance and exit of air and by the consequent increased pressure upon the drum-head.

386. The Internal Ear comprises the *labyrinth* and portions of the auditory nerve connected with it. The labyrinth is a hollow bony cavity. Its central portion, called the *vestibule*, is a sort of anteroom, the entrance to which from the middle ear (*i.e.* the oval opening or window) is closed by the foot-rest of the stirrup. Its upper and forward portion, the *cochlea*, or snail shell, is a tube coiled in a pyramidal form. Its lower and posterior portion is composed of the *semicircular canals*, three in number. The inside of the cochlea is divided into two passages, one above the other, connecting at the upper portion of the cochlea. The lower part of the upper one opens into the vestibule, near the oval window, while the corresponding part of the lower passage is near the round window, which is closed by a membrane.

A fluid called the *endolymph* fills the labyrinth. It is a part of the natural water of the brain and skull cavity.[2] When this fluid in the labyrinth is compressed by the pressure inward of the stirrup, it finds relief at the round window, by a slight yielding of the membrane. Lining the osseous labyrinth is the *membranous labyrinth*. Distributed in and upon it are the delicate filaments of

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[1] If, while a bather's head is immersed, two stones or shells be clashed together under the water, the sounds perceived by him will be almost deafening, and may permanently impair his hearing. Children should be extremely careful not to play this dangerous trick upon one another.

[2] A fluid between the membrane of the labyrinth and its bony encasement is called the *perilymph*.

the auditory nerve. Of this nerve there are two main branches,—the cochlear branch, supplying the cochlea, and the vestibular branch, supplying the remaining portion of the membranous labyrinth. The filaments of the cochlear nerve are distributed in a very complex manner

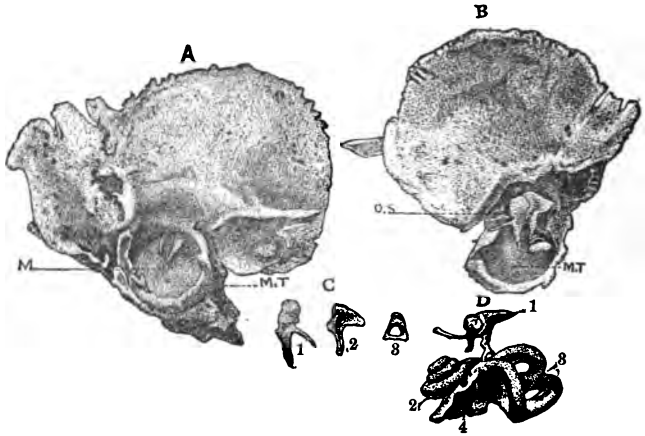

Fig. 111.

(From photograph by RUDINGER.)

A. Right temporal bone, auricle and external canal removed. — MT, membrana tympani, or drum-head; M, handle of malleus showing through.
B. Right temporal bone, inner side, petrous portion removed. — MT, the drum-head; OS, chain of bones in position.
C. The bones of the ear. — 1, the malleus; 2, the incus; 8, the stapes.
D. The relation of the bones of the ear to the bony portion of the internal ear. — 1, the ossicles, foot-rest of stapes, attached to oval window; 2, the cochlea; 3, the semicircular canals; 4, the upper end of Eustachian tube. The round window is not seen in the cut.

to the shelves of the cochlea, and end upon thousands of little hair-like cells, harp strings as it were, which are held in place upon the so-called *arches of Corti*.[1] The vibration of these hair-like cells is communicated to their

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[1] There are said to be about three thousand arches of Corti in the human ear, each one tuned to respond to the various musical sounds.

connecting nerve filaments, and thus to the auditory nerve and the brain. It is stated by physiologists that we hear noises with the vestibule nerves, and music with the cochlear ones.

387. It is supposed that, besides their connection with hearing, the semicircular canals have something to do with the *coördination of muscular movements*. Experiments on birds and other animals show that when these canals are injured, uncontrollable motions of the head ensue, followed by reelings and falls, and the inability to control the muscles involved in walking or flying; but neither consciousness nor the sense of hearing is impaired. Sometimes in persons with ear disease, similar manifestations occur on an attempt to walk, although consciousness is unimpaired. From the above circumstances, some speak of a sense of equilibrium, and locate it in the semicircular canals.

388. The Physiology of Hearing is briefly as follows: Sound waves are collected and strengthened by the auricle.[1] Passing down the external auditory canal, they strike the drum-head, and cause it to vibrate and set in motion the ossicles, which in turn, through the foot-plate of the stirrup bone, impart motion to the water of the labyrinth.[2] Through this fluid the impressions of the sound waves are conveyed to the membranous labyrinth,

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[1] In the lower animals, the auricles are true collectors of sound. In man they have to do with the quality of sound more especially, as any one can ascertain by gently pressing the auricle backward or forward when near a number of sounds, as of steam whistles, etc.

[2] The vibrations of the membrane of the oval window are probably transmitted through the perilymph and membranous labyrinth to the endolymph.

and thence to the brain, by the filaments of the auditory nerve which lie upon the membrane. To be able to hear distinctly, it is necessary that there should be an accurate arrangement of the various portions of the auditory apparatus, free movements of muscles, membranes, and bones, of the fluid of the labyrinth, and of the air outside and inside the drum cavity.

389. **Defective Hearing** may exist without the knowledge of the sufferer or of his friends. Of 570 school children examined in New York City,[1] 76 were found to be deficient in hearing, either in one ear or in both, while only *one* had been known by the teachers to be deaf, and only 19 out of the 76 were aware of aural defects.[2] Neglected inflammations of the throat, especially in those living in an impure atmosphere, and eruptive diseases (such as scarlet fever and measles, where inflammation extends into the Eustachian tubes) may cause deafness. Decayed teeth or inflamed gums, by reflex irritation through a ganglion near the ear, sometimes produce earache and temporary deafness.

Blows upon the ear are always dangerous, and may cause temporary or permanent deafness. Accumulation of ear wax is a very common cause of deafness.[3]

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[1] See circular of information of the Bureau of Education, No. 5, 1881.

[2] In conducting such tests, the voice is considered better than the ticking of a watch. The patient, having one ear stopped, should stand with closed eyes at various distances from the examiner, while the other ear is being tested. The sentences repeated should be intelligible and frequently changed, and should contain words with hissing and guttural sounds, these not being easily understood when hearing is impaired. Though this mode of testing is the best, it is not as accurate as the test for defective vision.

[3] A very large number of persons apply at the eye and ear infirmaries for relief from deafness, and obtain it after accumulated ear wax has been removed.

Cleaning the ear too frequently with swabs, or clearing out the wax with pin-heads, hair-pins, and other metallic implements, will be apt to excite inflammation,[1] and may facilitate the growth of fungi. Neglected diseases of the middle ear may result in brain disease, by inflammation through the mastoid cells. Ear diseases sometimes produce ringing and hissing sounds in the ear, which are very annoying. In certain forms of disease, the patient's own voice sounds loud and disagreeable to him.

390. Hygiene of the Ears. — To prevent catching cold in the ears, they should be washed frequently but gently, and in very cold weather may be protected by covering with a loosely fitting cap, tippet, or ear-tabs. Pressure or overheat will increase the perspiration and soften the skin. Draughts of air from open windows should be avoided. The habit of breathing through the mouth is injurious, as it dries the mucous passages of the ear, and thus interferes with hearing. Improper clothing, overheated rooms, or wet feet may cause inflammation of the ear. Prolonged bathing in cold water and diving from a height should be avoided. When about to dive, or swim under water, a pledget of cotton in each ear is advisable; but the prolonged wearing of cotton in the ears makes them sensitive.

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[1] The habit of probing and scraping the external ear is injurious; it excites the ceruminous glands to pour out a superabundance of wax, which impairs hearing, and is an annoyance to those who desire to appear cleanly. A graver harm also may be done, such as wounding the delicate lining of the ear, or puncturing the drum membrane, or displacing the little bones. The best way to cleanse the external ear is carefully to inject warm water, or warm water with a little good soap dissolved in it, with no scraping, and little or no swabbing. Any substance not easily removed by syringing had better be left to the care of a physician.

391. Effects of Alcohol and Tobacco upon Hearing.— Alcohol and tobacco sometimes produce such irritation or dryness of the Eustachian tubes as to cause a more or less troublesome deafness, ringing in the ears, or other uncomfortable sounds.

QUESTIONS.

1. How is hearing effected?
2. What is meant by the intensity of sound? the pitch? the quality?
3. What is the capacity of the ear to distinguish different sounds?
4. What is the organ of hearing, and its divisions?
5. What does the external ear comprise?
6. Describe the auricle and its use.
7. Describe the auditory canal.
8. What glands are located in the external ear?
9. Describe the *membrana tympani*, or drum-head.
10. What is the middle ear, and what does it comprise?
11. Where are the mastoid cells?
12. Describe the contents of the drum cavity.
13. How do the small bones of the cavity and the fluid of the labyrinth act, to enable us to hear?
14. Describe the Eustachian tube and its uses.
15. What is the effect of its stoppage?
16. What does the internal ear comprise?
17. Describe the labyrinth, and its several divisions and contents.
18. What is distributed throughout the labyrinth to convey the auditory impressions to the cerebrum?
19. What is the belief of physiologists as to the function of the semicircular canals, and on what is this belief founded?
20. What is the physiology of hearing?
21. What may be said as to the prevalence of defective hearing, and to what causes in general is it due?
22. What are some of the consequences of ear diseases?
23. What care should be taken of the ears, and what precautions used?

CHAPTER XX.

THE VOICE.

392. Voice: Speech. — All animals, except the very lowest types, possess some audible method of communicating with their fellows,[1] — *i.e. the voice.* Some are incapable of producing more than one kind of sound, — a monotonous cry, — while the sounds emitted by others admit of considerable variation. The dog's notes of welcome to his master are very different from the harsher tones with which he greets intrusive strangers. *But to man alone is it given to express thoughts in articulate sounds or speech.* Between the higher and lower races of mankind there is a great difference as to the use of the voice, in both language and song, and its development is usually in direct relation to the intelligence of the races. Idiots, notwithstanding their possession of a normal vocal apparatus, cannot always converse intelligibly, but resemble some of the lower animals in the character of their vocal sounds. Parrots and other birds can be taught, by constant repeti-

[1] Among insects this is sometimes accomplished by the rapid vibrations of wings, the tapping of antennae or limbs upon some resonant object, or the rubbing of hard portions of the body against each other, the leg against the wing, for instance, as in the locust family. Sir John Lubbock claims that bees can vary their hum so as to express their feelings. The common domestic fowl emits one kind of sound when quietly employed in scratching for food, and another when a hawk approaches. The crane has a marvellously constructed trumpet, for use especially at night and when taking long flights.

tion, to repeat difficult words and sentences, and to imitate cries, laughter, and sobbing; but, so far as we know, they do not originate words or sentences.

The development of speech is intimately connected with the acuteness of the special senses, for it is through them that we gather impressions which develop into ideas, and thence into language. This is especially true of the hearing. By persistent and painstaking efforts, some who have been born deaf have been taught to articulate, and even to converse, but without that delicate modulation of tone and accentuation and emphasis of words which can be given only by a regulating ear; and the limited power thus laboriously acquired is, after all, exceedingly precarious and easily lost (*a*).

393. The Organs of Voice are the larynx (Fig. 80) and its accessories, the windpipe, lungs, respiratory muscles, pharynx, mouth, and the nasal cavities. All of these parts are necessary for the proper modulation of the voice. The mechanism required for its production may be compared to that of a reed organ, the lungs corresponding to the bellows which supply air, the bronchial tubes and trachea to the wind chest which conducts the air, the larynx, with its vibrating cords, to the vibrating reed of the organ, and the pharynx, mouth, and the parts in connection with them, to the body tube or resonant pipe, which modifies the sounds produced.

394. The Larynx.—Its framework is composed of nine cartilages, connected by ligaments and operated by numerous muscles. It is lined by mucous membrane, and is well supplied with blood-vessels and nerves. The largest of the four principal cartilages is the *thyroid*, or shield

cartilage, a broad, thin plate, shaped something like the cover of a half-open book, and joined to the hyoid bone above by a membrane. The back of the book represents the ridge of the thyroid cartilage, as seen or felt in the front of the neck, and familiarly known as Adam's apple. Below the thyroid cartilage, and attached to it by an encircling membrane, is the second of the four cartilages, the *cricoid*, which is shaped like a seal ring, with the narrow portion in front. Lastly, upon the posterior and upper surface of the cricoid are two slight eminences for articulation, with two pyramidal and very movable cartilages, called the *arytenoids*.[1]

Surmounting the arytenoid cartilages are two very small ones, known as the supra-arytenoid, or buffer, cartilages, which deaden and distribute pressure, and serve to prevent injury to the larynx, especially in swallowing. Attached by its lower and narrow end to the inner and upper part of the thyroid cartilage is the *epiglottis*, or cover cartilage, shaped something like a lilac leaf. Its principal function is to assist in preventing the entrance of food or other articles into the larynx during the act of swallowing. At such times the larynx is raised, its walls are approximated, and the epiglottis, as a lid, covers the opening of the glottis. On looking into the throat during a full inspiration, the rounded, free, upper edge of the epiglottis is sometimes visible behind the base of the tongue. Within the folds of the mucous membrane, stretching from the epiglottis to the arytenoids, are two other cartilages, long and sickle-shaped, termed *prop* cartilages, which assist in keeping the larynx open.

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[1] *I.e.* like a pitcher, so called because when joined together they resemble the beak, or mouth, of a pitcher.

395. The Vocal Bands. — Intimately concerned in the production of voice are the *vocal bands* (or cords) and the muscles of the larynx. The former are two horizontal elastic bands of ligament, stretched across the larynx from front to back. They are attached in front to the angle in the thyroid cartilage, just below the attachment of the epiglottis (one on each side of the interior of the larynx), and are there comparatively immovable, while at the back they are attached to the very movable arytenoid cartilages.[1] By the contraction and relaxation of these bands the opening between them, known as the glottis, is enlarged or diminished in size during respiration, and for the production of voice.[2]

396. Muscles of the Larynx. — The tension and degree of approximation of the cords is variously modified through muscles, and thus in part is produced the various differ-

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[1] Their arrangement allows the edges or margins to be sharply defined, and to vibrate as the air passes over them. These bands are sometimes called *true vocal cords*, to distinguish them from two membranous folds lying above them, known as *false vocal cords*, because they are not concerned in the production of the voice.

[2] "You know musical chords or strings, as those of the guitar, violin, etc., are attached only at their two ends, so that they can freely vibrate between; the tongues or reeds of organs, accordeons, clarinets, and all other artificial reed instruments, are usually attached at one end only, so that they have three free edges; but the human reeds or vocal bands are attached on three sides, and have only one free edge. Those of you who know what a large number of reed or organ pipes are needed in the organ made by man, to produce the notes of varying pitch and timbre, cannot fail to be struck with astonishment at the fact that in the organ in man's body a single reed-pipe, the larynx — by a wonderful power of variation inherent in itself — suffices for the production of the most various sounds. No musical instrument has ever been constructed by man that approaches in perfection or effectiveness that of the human voice." — Dr. Louis Elsberg, *The Throat and its Functions*.

ences of sound which make up the human voice. Some of the muscles of the larynx move and rotate the arytenoids outwardly, thus separating the vocal cords and widening the chink of the glottis. Others move and rotate the arytenoids inwardly, thus approximating the vocal cords, and, in a varying degree, closing the glottis. The remaining muscles of the larynx serve to regulate the tension of the cords, or are concerned in respiration, or act upon the epiglottis during the act of swallowing. The nerves which supply the mucous membrane of the larynx with sensibility and the muscles with motor power are four in number.

Fig. 112.

Posterior View of Larynx.

T, base of tongue.
TH, upper part of thyroid cartilage (the epiglottis is seen between the upper portions of this cartilage and behind the tongue).
CC, the cricoid cartilage.
AC, arytenoid cartilages, hid in part by muscles.
TR, trachea.
1 and 2, nerves of larynx, branches distributed to the tongue, to the epiglottis and the folds of membrane between the epiglottis and arytenoids, and to muscles controlling the action of the cricoid and arytenoid cartilages.

397. Mechanism of the Production of Voice. — Before the introduction and use of the laryngoscope,[1] there was much uncertainty as to the mechanism for the production

[1] An oval or round mirror attached to a long handle, which, placed in the back and upper part of the throat, reflects the interior of the larynx, and, under favorable conditions, a part of the trachea. This instrument

of voice. An examination of the interior of the larynx with this instrument during ordinary respiration shows the chink of the glottis to be quite wide during inspiration, but much narrower during expiration; for in the latter case the muscles of the larynx are passive, air being gently forced out. During vocalization the vocal cords are particularly well defined. Speech is shown to be effected during expiration only, though harsh sounds may be formed during inspiration. As soon as an attempt is made to produce a sound, the cords are thrown into action. In the production of high musical notes or shrill sounds, they are made tense and are closely approximated, and are relaxed and moved further apart during the emission of sounds opposite to these.

Fig. 113.

View of the interior of the larynx during respiration. Rings of the trachea seen through the laryngeal opening, the vocal cords (represented in white) being apart.

398. For the production of clear vocal sound, the cords must be brought into close approximation and must be capable of easy vibration. If they cannot so approach each other, whispering results. If they are not sufficiently smooth or straight, or if their action is irregular, or if they have on their

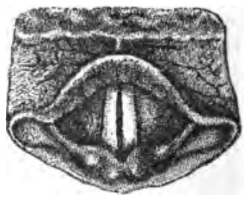

Fig. 114.

The Position of the Vocal Bands during Phonation.

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originated from the observations of the celebrated singing teacher, Garcia, upon himself, and the investigations of two Austrian physicians, Turck and Czermak. The first successful demonstration of the action of the vocal cords is said to have been made by Garcia in 1854.

edges flakes of mucus, the tones become rough and hoarse in character.[1]

Stammering is caused by a spasmodic contraction of the diaphragm, interrupting expiratory efforts. "The stammerer has control of the mechanism of articulation, but not of the expiratory blast. He must control his respiratory muscles, to steady their action during speech. A *stutterer* has control of these muscles and of the diaphragm, but his lips and tongue are insubordinate."

399. Variations in Vocal Sounds depend mainly upon their *intensity*, *pitch*, and *quality*. Intensity, or loudness, depends upon the elasticity of the vocal bands and the force of the escaping air. The more relaxed the bands and the stronger the current of air over them, the larger are the sound-waves and the louder the sounds produced.

Differences in pitch depend upon the rapidity with which the bands vibrate. The more rapid the vibrations, the higher the pitch. The slower they are, and the less closely the cords approximate, the lower the sound.

Quality, or timbre, is that characteristic by which we can distinguish different voices, and recognize the voices of our friends, even though their features may be concealed. Quality is of a composite nature, and is due to the more or less harmonious relations between intensity, pitch, and other characteristics of sound. It depends largely upon the condition of the resonant cavities of

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[1] The varying tones produced by two elastic bands more or less parallel with each other, and with edges of varying rigidity, may be illustrated by blowing through glass tubes of different length and caliber, to the opposite ends of which two pieces of thin rubber cloth are firmly fastened, the free edges being parallel, or nearly so.

the throat, mouth, and nose. Enlarged tonsils, loss of teeth, dryness of the mucous membrane, cleft palate, hare-lip, and other defects change the quality of vocal sounds. Our vowel sounds are clearly enunciated only when the sounding breath is not obstructed above the larynx in its outward passage. With the mouth wide open, only a harsh sound can be made by the vocal bands. Consonant sounds result when there is an obstruction by the lips, tongue, teeth, etc., to the outward motion of the air. The position of the tongue and of the soft palate favors the emission of certain sounds. A nasal twang is the result of talking with the nose or the passages thereto from the lungs more or less obstructed. It is not so much because we talk through the nose, as because we do not use the nasal vent with sufficient freedom. It is called a nasal twang, because the closed or contracted nasal apertures have caused unpleasant modification of the sound.

The different qualities of voice depend not only upon natural variations in the larynx and the accessory organs of speech, but also upon the degree of culture to which the voice and its organs have been subjected.[1] In some persons the voice is so perfectly modulated that it never seems too high, too low, too harsh, or too flat.[2]

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[1] Among the Greeks, for the training of the voice there were three sets of teachers, the first to develop power and range of voice, the second to improve the quality, the third to teach modulation and inflection.

[2] The capabilities of some voices are almost incredible. It is related by Mrs. Seiler, in her manual on "The Voice in Singing," that the singer, Farinelli, once competed with a trumpeter who accompanied him in an aria: "After both had several times dwelt on notes, in which each sought to excel the other in power and duration, they prolonged a note with a double trill in thirds, which they continued until both seemed to be exhausted. At last the trumpeter gave up, entirely out of breath,

There is also a property of voice known as *reach*, *i.e.* "the penetrant power of a sound over distances and obstacles, such as other sounds, and is due to the purity of the tone, which in its turn is dependent on the accuracy with which it is produced." At the Peace Jubilee in Boston, in 1869, Madame Parepa Rosa's voice was distinguishable above those of an accompanying chorus of nearly 12,000 singers and an orchestra of 1000 instruments, in a hall where the audience consisted of 40,000 people.

The ordinary *range* or *compass* of *the voice* is about two octaves, seldom less than one or more than two and a half. In some great singers the range is three and a half.[1]

400. Ventriloquism.—The peculiar mode of speaking known as *ventriloquism* is a curious modification of the voice, and is not, as the word literally means, "talking from the stomach." The power of the ventriloquist is sufficiently marvellous without our attributing it to a still more marvellous source. Without apparently moving his lips, by some occult management of the vocal organs, by great skill in mimicry and considerable address in appealing to the imagination, the ventriloquist causes different human voices, animal cries, and other noises to seem to issue from persons or objects outside of himself. This remarkable power may account for many

while Farinelli, without taking breath, prolonged the note with renewed volume of sound, trilling, and ending finally with the most difficult of roulades."

[1] The entire range of the human voice exceeds five octaves, for there have been bassos who sang with ease and power the lower F of 40 vibrations, and sopranos who readily reached the high F of 1400 vibrations, or even the higher C of 2000 vibrations.

of the wonderful responses which are said to have been made by the ancient oracles.[1]

401. The Chief Varieties of Voice are four in number; viz., the bass and tenor in the male sex, and the contralto, or alto, and the soprano, in the female. There is a variety of voice between the bass and tenor, known as the baritone; and one between the alto and soprano, called the mezzo-soprano. Ordinarily the strength and beauty of bass and contralto voices are in the lower notes, and of soprano and tenor in the higher. Bass singers may reach as high notes as tenors, and alto singers as sopranos, or *vice versa*, but they do not attain the proper clearness and richness of tone. A falsetto voice is one pitched above its natural compass. In early childhood, the character of the voice is about the same in both sexes. The quality of the soprano voice in boys is often especially prized in the rendering of church music. At about the age of fourteen years, the boy's voice begins to change. The larynx increases in size, the power of regulating its muscular control is diminished, and the falsetto voice is likely to break in upon the ordinary voice, especially in

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[1] "From the observations of Müller and Colombat, it seems that the essential mechanical parts of the process of ventriloquism consist in taking a full inspiration, then keeping the muscles of the chest and neck fixed, and speaking with the mouth almost closed, and the lips and lower jaw as motionless as possible, while air is very slowly expired through a very narrow glottis, care being taken, also, that none of the expired air passes through the nose. But, as observed by Müller, much of the ventriloquist's skill, in imitating the voices coming from particular directions, consists in deceiving other senses than hearing. We never very readily distinguish the direction in which sounds reach our ear; and when our attention is directed to a particular point, our imagination is very apt to refer to that point whatever sounds we may hear." — KIRKE, *Handbook of Physiology*.

declaiming and singing.[1] The voices of girls change somewhat at about the same age; they develop strength and compass, the quality remaining about the same. But with both sexes at this period *there should be no systematic cultivation of the voice.*

402. Hygiene of the Voice. — *Weak and improperly modulated voices can be improved by proper care and culture.* To this end all diseased conditions, such as enlarged tonsils, adenoid growths,[2] a very relaxed soft palate, nasal or pharyngeal catarrh,[3] defective teeth, etc., should be remedied, and muscular exercises, adapted to the wants of each individual, should be systematically practised. The muscles of the diaphragm and those of the chest may be exercised by occasional full respirations, and by the hands being placed against a wall, and the chest moved forcibly toward and away from the wall.

"The muscles of the larynx are best exercised by systematic singing exercises on the tones at or near the middle of the ordinary compass of the individual." Repetitions of the act of swallowing, and various movements of the lips, cheeks, and tongue, are valuable. Wind instruments, adapted to the strength of the performer, are also of

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[1] The high-pitched voice of children is due to the small size of the larynx and the short vocal cords.

[2] Adenoid growths, spoken of in Chapter XIII., occur in about ten children in every hundred, causing catarrhal inflammation of the throat, and sometimes deafness. They force the child to breathe through the mouth, and diminish the air supply to the lungs. "There is no such thing as a healthy throat in an individual who breathes through the mouth as a habit."

[3] "One of the commonest causes of nasal and throat catarrh in childhood is indigestion, and the commonest cause of indigestion is the habit of eating rapidly and washing food down with fluids during a meal."

service in some cases; but if they are too powerful or are used excessively, injury to the lungs is likely to result. In particular, the voice should be frequently used in a natural and proper manner. Spasmodic and prolonged use, especially if the voice is pitched too high, strains the vocal apparatus, and produces inflammation of the mucous membrane of the throat. The forced and unnecessary chest respirations sometimes indulged in by public speakers and singers place the thorax and larynx in tiresome and constrained positions, and interfere with the natural use of the voice.

The training of the voice should begin in childhood, when the vocal organs are most pliable. It should be entrusted to competent teachers, and, like other forms of muscular exercise, should be pursued systematically and daily, but never to the point of fatigue. It is related of a celebrated musician that, in answer to an inquiry why he practised so systematically, he replied, "If I neglect to practise one day, I notice it; if for two days, my friends notice it; and if for three, the public notice it."

Even in adult life, the strength and quality of the voice may be improved, and clergymen, actors, and other public speakers have had their usefulness increased by lessons in elocution and the care of the voice (*a*).

403. Effects of Alcohol and Tobacco upon the Voice. — Alcohol sometimes produces huskiness of the voice, by thickening the lining membrane of the larynx and weakening the laryngeal muscles. Tobacco, especially if the smoke from it is inhaled, sometimes sets up a troublesome and persistent hacking cough, due to a dryness of the mucous membrane and irritation of its sensitive nerve filaments.

QUESTIONS.

1. What is to be said of the audible means of communication of men and animals, and on what does its development depend?
2. With what is the development of speech intimately connected?
3. What parts of the body are concerned in the production of voice?
4. Which is the special, or essential, organ of voice?
5. Describe the larynx, its cartilages, vocal cords, and muscles.
6. How are the differences of sound of the voice produced?
7. How has the mechanism for this purpose been ascertained?
8. What does an examination of the interior of the larynx with the laryngoscope reveal?
9. How are sounds produced, and why are some sounds musical and others not?
10. What causes the differences in their intensity? pitch?
11. What is the quality of a voice, and on what does it depend?
12. What is ventriloquism?
13. What is reach?
14. What is said of the range or compass of the human voice?
15. What are the chief varieties of voice?
16. How and when do the voices of boys and girls change?
17. How is the voice modulated to produce the various articulate sounds?
18. What is to be said of nasal sounds? of clearness of voice?
19. Give general directions for the care and culture of the voice.

EMERGENCIES.

404. The following directions as to the care of the injured will often save life, if carefully followed. "In many cases of injury the crisis is reached before the patient arrives at the hospital gate, and the lack of instructed aid at first often turns the tables against him." Officiousness on the part of bystanders is likely to do harm.[1] Whenever practicable, a physician should be sent for and the injured person given into his charge. When called, the doctor should be informed of the nature of the accident, that he may bring with him the proper appliances and restoratives.

General Directions.

405. *First. Do not join the crowd about an injured person unless you can be of service.* As the throng increases in numbers and presses more closely about the sufferer, his chances for recovery are lessened; his air supply is diminished, and the efforts of those assisting him are interfered with. At least ten feet of space on all sides of the injured person should be kept clear, except for those actually concerned in caring for him.

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[1] To replace officiousness with efficiency is the aim of the Red Cross Societies in this and other countries.

Second. If you withdraw, take as many idlers as you can with you. If no one has assumed charge of the case, take it in hand, going quickly but calmly to work; but, if there is already a leader, offer to go for a doctor, blankets, or stimulants, or to do whatever is desired. Do not argue with others who are assisting, as to methods of work, for *delay imperils the life of the one you desire to save.* On the other hand, do not proceed too rapidly. For example, do not attempt to administer stimulants before the injured person can swallow.

Third. The injured person should be examined with the greatest care. Rough handling may open a wound in which bleeding has ceased and start a dangerous hemorrhage, or cause the jagged end of a broken bone to wound seriously an important blood-vessel or nerve. Thoroughly examine the entire body, in search of broken or dislocated bones, wounds, unusual swellings or depressions. Note whether the face is flushed or pale, whether the pupils respond to light, whether the breathing is quiet and regular, or noisy, or difficult; also note the condition of the pulse. A pale face indicates faintness; flushing, too much blood in the head. If the pupils do not respond to light, or if the breathing is noisy, there is danger of apoplexy.

Fourth. If the pulse is easily compressed by your finger, the patient's heart is beating feebly, and there is danger of life's ebbing away; therefore stimulants are needed. If the face is flushed or the pulse strong (*i.e.* not easily compressed), stimulants are dangerous.

When the skin is cold, restore warmth by gentle friction with the hands, and by applications of heated flannels and bottles filled with hot water, especially to the feet, about the body, and in the armpits. If the head is very hot, cold water or pieces of ice may be applied to it. The

injured person generally needs abundance of air, and it may be necessary to create a current by the use of a fan; but, at the first evidence of chilliness, the patient should be covered with blankets, shawls, coats, etc., though not so heavily as to induce perspiration. If the person needs stimulants and is able to swallow, give fifteen drops of aromatic spirits of ammonia in one-third of a glass of water; or brandy or whiskey, one part to four or five of water. Repeat every fifteen minutes, if prostration continues.

Fifth. To remove an injured person, use as a stretcher a strong shawl or sheet doubled and suspended between two poles, a board, a door, a window shutter, a ladder, or something similar. If the distance is short, the patient may be carried by two persons, with hands so locked as to form a chair. If the distance is great, an ambulance may be devised by placing one or more mattresses in a covered vehicle of sufficient size. In lifting an injured person, three attendants are generally required: two to support the body, while one attends to the injured part. When about to convey by a stretcher, depute some one to keep back the crowd, while another goes before to secure a comfortable shelter. Cover the face of the injured one with a handkerchief or other light article, to prevent the uncomfortable feeling of being stared at. He should be instructed not to answer the questions of mere idlers.

Unconsciousness.

406. Unconsciousness may be partial or complete, and may be caused by concussion of the brain, by shock from physical injuries or mental emotion, by apoplexy, epilepsy, narcotic poisons, loss of blood, or by blood poisoning, as

in some forms of kidney disease. If there is entire insensibility, an arm, when lifted and let fall gently, offers no muscular resistance, but is a dead weight; the pupil of the eye does not contract on exposure to light; and no effort to close the lids is made when the operator's finger is brought quickly toward the eye. If unconsciousness is partial, or if it is feigned, as in some cases of hysteria, the conditions are the reverse.

407. Fainting.—The danger here is from a feeble heart. The pulse is weak, the face pale.

Treatment. A few minutes of rest may bring about recovery, the person being *laid flat upon his back*, with all impediments to free breathing removed. If there is vomiting, place him on his side. A dash of cold water upon the face, tickling of the nostrils, the inhalation of the vapor of smelling salts or ammonia, and the use of strong coffee or of stimulants internally may be necessary.

408. Intoxication.—*Symptoms.* Breath has the odor of liquor;[1] unconsciousness, more or less complete; usually can be roused; breathing quiet; pulse frequent; pupils slowly respond to light.

Treatment. Generally, more vigorous measures should be employed than for fainting; viz., slapping of the face, tickling or slapping of the soles of the feet, and twisting of the hair. If there are symptoms of collapse (*i.e.* cold skin and feeble pulse), apply warmth and give coffee or

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[1] Sometimes a temperate person, rendered unconscious from a severe accident, is treated as if intoxicated, when the breath smells of liquor, which has been taken by him because of faintness or exhaustion. Such a mistake not only causes an utter neglect of measures necessary for recovery, but leads to great injustice and mortification.

aromatic spirits of ammonia. It must be remembered that intoxication may be associated with more alarming forms of unconsciousness, such as apoplexy, in which case too vigorous restorative measures may imperil life.

409. Apoplexy. — *Symptoms.* Patient generally unconscious; face flushed or very pale; pulse full; pupils do not respond to the light; breathing more or less noisy; paralysis of one side of face or of one or more of the limbs; sometimes convulsions.

Treatment. Place in recumbent position, head raised a little; loosen the clothing about the head, neck, and chest. If head is hot, apply ice or cold water. *Keep patient quiet.* Leave other means to the doctor.

In concussion of the brain, as from a blow upon the head, the symptoms resemble those of apoplexy. Fracture of the base of the skull is generally indicated by bleeding from the ear.

410. Convulsions or Fits. — Do not attempt to hold the patient still. Merely prevent him from injuring himself. If there is danger of the tongue being bitten, place a piece of wood between the teeth. In the ordinary convulsions of children, from undigested food, etc., and in convulsions from blood poison, place the patient for a few minutes in a warm bath. If the head is hot, keep cold water applied to it during and after the bath. If convulsions continue, produce vomiting by administering one teaspoonful of syrup of ipecac, and a movement of the bowels by an enema of soap and warm water.

In the convulsions of epilepsy, these measures are not necessary. Simply keep patient from hurting himself. Do not struggle with him.

411. Sunstroke and Heat Exhaustion are two conditions entirely different, but both are caused by fatigue and prolonged exposure to great heat. They are most likely to occur among feeble and intemperate persons, among those who work under the direct rays of the sun or in badly ventilated and overheated rooms, or among those who wear too much clothing (especially heavy head-coverings) in hot weather and use iced drinks to excess.

Symptoms. In sunstroke, the skin is usually hot, pulse full, and breathing labored, and the patient may be unconscious. There is danger from congestion, which occurs in the internal organs. In heat exhaustion, there is coldness, pallor, and weak pulse.

Treatment. Recumbent posture in a cool place, ice to the head, and cold douches upon the face, neck, chest, and spine, attended with friction until consciousness returns. Stimulants are required if the pulse is very weak; and if reaction does not soon set in, mustard (but not to blister) may be applied to the feet, the back of the neck, and the chest. When there is apparently no active congestion, but evidences of heat exhaustion, stimulants are to be used from the first, and cold applications sparingly, if at all. It may be necessary to induce warmth of the body, but this should be done in a cool room. Rest in bed is important.

412. Suffocation.—*Drowning, Smothering, Hanging, and Gas-poisoning* constitute a group of accidents in which death results mainly from a deprivation of air.[1] Carbon dioxide, accumulating in the blood, poisons the nerve centres in the medulla, checks breathing, and may stop

[1] In accidents of this kind, the face is generally swollen and of a bluish color; sometimes the eyes and tongue protrude; about the mouth is more or less mucus, occasionally streaked with blood.

the action of the heart. Animal heat is also lost, sometimes entirely, so far as we can perceive.

In all cases of suffocation, *oxygen is to be supplied*, *circulation of the blood reëstablished*, and *animal heat restored.*

Treatment. 1. Cut or tear clothing from face, neck, and chest, and expose patient to the open air, except in very severe weather. Valuable time is lost by endeavoring to untie or unbutton clothing.

2. If the jaws are clenched, separate them, and keep the mouth open by placing a cork or a bit of wood between the teeth.

3. With the index finger covered with a handkerchief or piece of cloth, remove from the mouth mucus or any other substance which may prevent the ingress of air.

4. In nearly all cases of suffocation the tongue is relaxed and sometimes swollen, and may fall back into the throat, blocking the entrance for air. If you are obliged, without assistance, to resuscitate any one, practise artificial respiration, as hereafter described in § 413, *First Method.* The head of the patient being kept lower than the body, and face downward, the tongue will fall forward by its own weight. If you have an assistant, he should pull the tongue forward with a cloth, and hold its tip firmly out of the mouth, the patient being on his back.[1]

5. Heat is to be restored by warm, dry blankets, and friction under them; by the application of hot flannels, bottles of hot water, or heated bricks, to the pit of the stomach, the armpits, the sides, the feet, and between the thighs.

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[1] In the resuscitation of very heavy persons, whom you cannot lift from the ground, if you have no assistance, put a strip of cloth over the tongue pulled forward, and hold it in place by tying the cloth at the back of the neck, or fasten it by an elastic band passing over it and under the chin.

6. In cases of partial suffocation, it is often sufficient to loosen the clothing about the neck, slap the chest with a cold wet towel, expose the patient to the open air, and allow him to inhale the fumes of ammonia; administer stimulants, if necessary, and keep him free from excitement while recovering. When the patient does not breathe, perform artificial respiration, as directed under head of "Drowning."

413. Drowning.—*Treatment.*[1] 1. *To remove water from the air passages.* After loosening clothing which interferes

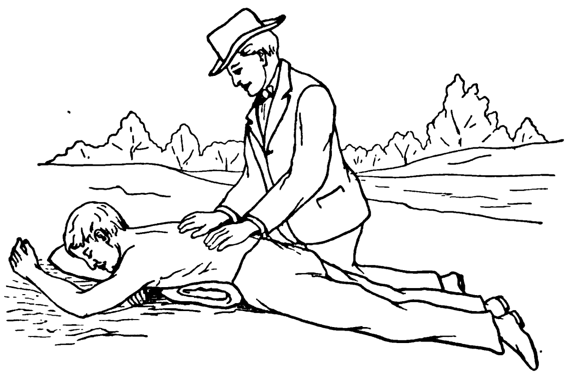

Fig. 115.
Removing Water—Patient on Ground.

with breathing, clearing the mouth, and seeing that the tongue does not fall back into it, remove water from the

[1] The following instructions for rescuing drowning people should be remembered: "Approach the drowning from behind, seizing them by the collar, or a woman by the back hair, and towing them at arm's length to boat or shore. Do not let them cling around your neck or arms to endanger you. Duck them under until unconscious, if necessary to break a dangerous hold upon you; but do not strike to stun them."

air passages as follows: place the person face downward over your knee, or upon the ground with a large roll of clothing beneath the stomach, and press on the back over the stomach for a half minute; or, the patient

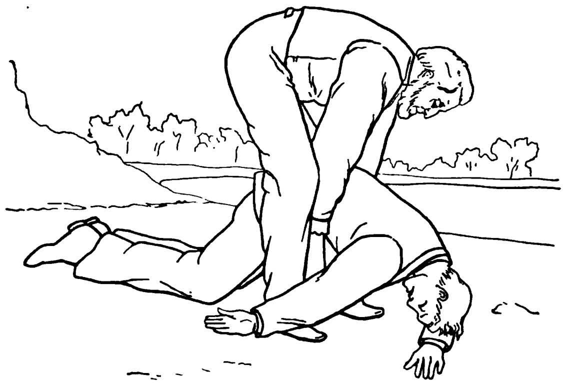

Fig. 116.
Removing Water — Clasping under Chest.

being face downward, stand astride his hips with your face toward his head, and raise him two or three times with a slight jerk, your hands being clasped under the lower part of his chest.[1]

2. *Artificial Respiration.* Now, *without delay* (unless the person is breathing) commence *artificial respiration.* Continue this for two hours or more, if neces-

[1] To hold a body up by the heels, so that the water may run out, is unnecessary. Rolling a body upon a barrel is a barbarous custom, attended with the danger of injury to internal organs, and is not to be tolerated. It is seldom that any large quantity of water enters the lungs or stomach. Some water is usually drawn into the air passages, unless the person faints when immersed.

sary,[1] while assistants are constantly trying to arouse animal heat, by rubbing the extremities and in other

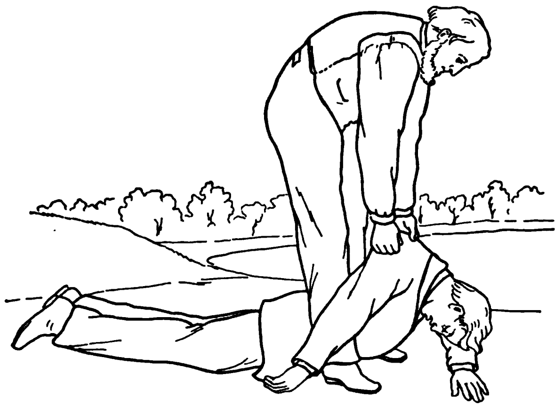

Fig. 117.
Artificial Respiration — Michigan Method.

ways before described, without hindering artificial breathing, which is the *one remedy* not to be lost sight of.

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[1] After how long a period of immersion in water a person may be resuscitated is not definitely known, and depends on various circumstances. If water has passed into the throat, air is excluded, and suffocation is prompt. So also if the drowned person has been tossed about in the surf. On the other hand, if the drowning person is able to control respiration, and lift his head occasionally above the surface, life will be prolonged, and the chances for resuscitation are increased. Such also is the case if fainting occurs, as respiration and the heart's action cease through the action of the nervous system, and there are consequently no respiratory or circulatory efforts demanding air for the purification of the blood. It may be noted here that many persons, even good swimmers, are drowned by reason of being seized with cramps or spasmodic contractions of muscles which cannot be controlled. Persons who are subject to cramps or twitching of the muscles, or who are debilitated, should not venture into water beyond their depth.

First Method. Keep the patient face downward, maintaining all the while your position astride the body, grasp the clothing over the points of the shoulders, — or, if the body is naked, thrust your fingers into the armpits, clasping your thumbs over the points of the shoulders, — and *raise the chest as high as you can* (Fig. 117) without lifting the head quite off the ground, holding it long enough to count *slowly* "one, two, three." Replace him

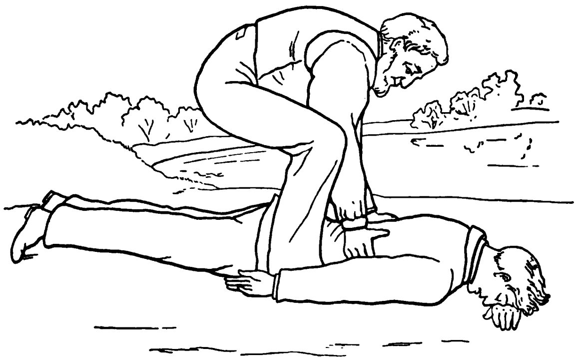

Fig. 118.
Artificial Respiration — Michigan Method.

on the ground, with his forehead on his flexed arm, the neck straightened out, and the mouth and nose free. Place your elbows against your knees and your hands upon the sides of his chest (Fig. 118), *over the lower ribs, and press downward and inward, with increasing force,* long enough to count slowly "one, two." Then suddenly let go, grasp the shoulders as before, and raise the chest (Fig. 117); then press upon the ribs, etc. (Fig. 118). These alternate movements should be repeated ten to

fifteen times a minute. Use the same regularity as in natural breathing.[1]

Second Method. After getting rid of the water, turn the patient quickly on his back, placing a roll of clothing under the back, so that the short ribs bulge prominently forward and are raised a little higher than the level of the mouth. Have the tip of the tongue held out of a corner of the mouth by a handkerchief in the hand of a bystander, and the arms stretched forcibly back above the head. Then kneel astride or beside the patient's

Fig. 119.
Artificial Respiration — Government Method.

hips, with your hands resting on the abdomen; spread out your fingers so that you can grasp the waist about the short ribs. Throw all your weight steadily forward upon your hands, squeezing the ribs at the same time as if you wished to force everything in the chest upward out of the mouth. Continue this movement while you count slowly "one, two, three"; then suddenly let go with a final push, which springs you back to your first kneeling position. Remain

[1] This is the method advised by the Michigan State Board of Health, and has the merit that it can be carried out by one person, if the patient is of light enough weight to be lifted readily.

erect upon your knees while you count "one, two," then throw your weight forward as before. Repeat all these motions with regularity; at first, four or five times a

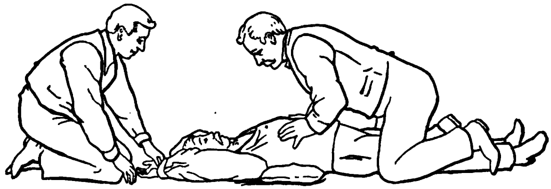

Fig. 120.
Artificial Respiration — Government Method.

minute, gradually increasing the rate to about fifteen times a minute.[1] If natural breathing be not restored, after three or four minutes, turn the patient over on his

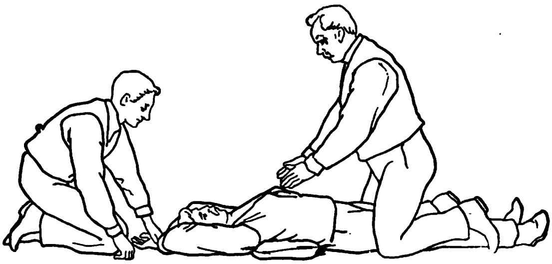

Fig. 121.
Artificial Respiration — Government Method.

face, with a roll of clothing under the stomach, and press firmly for a half minute on his back; then turn him over on his back and renew artificial respiration.

[1] Method of Dr. Howard, advised by the United States Life Saving Service. It requires two operators. Both in this method and in that advised by the Michigan State Board of Health, assistants are necessary to restore heat, etc.

3. *After Treatment.* After the person breathes, carry him promptly to a house, or under cover, and if possible put him in bed. See that he is thoroughly dry and warm, using friction, blankets, and hot applications, as already indicated. If warmth is not readily established by these means, a warm bath may be given, the body being immersed to the neck for not more than four or five minutes.

When the patient is able to swallow, slowly administer sips of hot coffee, hot water and brandy, or aromatic spirits of ammonia and water. Keep him quiet and warm in bed, in a well-ventilated room, for forty-eight hours or more, if necessary, and encourage sleep. Sometimes, even after he seems on the road to recovery, distressed breathing will occur, from a secondary congestion of the weakened lungs, brought on by excitement or by moving about too much. Large mustard plasters applied to the chest will help to relieve this condition. If this fails, the desired end may be gained by *carefully* repeating the artificial breathing, or by slapping the chest with a towel wet in cold water, or by holding ammonia to the nostrils.

Various Injuries.

414. **Burns and Scalds.**—Burns are caused by contact of the body with fire, heated substances, or chemical agents; scalds, by contact with steam or boiling liquids. The danger in either case is from shock, and from inflammation of internal organs. It increases, generally, in proportion to the nearness to the vital organs, the amount of surface injured, and the destruction of the underlying tissues.

If you see a person on fire, act promptly. Pick up the nearest rug, shawl, table-cover, overcoat, or slip of

carpet. Hold it before you to protect yourself, as you wrap it around the burning part, keeping the flames as much as possible from the face of the sufferer, so as to prevent the entrance of overheated air into the lungs. If necessary, throw the burning person to the ground and roll him over and over in blankets, carpets, or other woollen materials, and extinguish burning material with water.[1]

Treatment. 1. Remove the clothing about the injured parts, as far as possible, by cutting, being careful not to tear blisters open. Soften by water all adherent pieces of clothing. Cover the burned or scalded places with strips of soft linen or cotton cloth (not with cotton batting, for it adheres too closely, and is too heating), saturated in a mixture of carbolic acid, glycerine, and olive oil, one teaspoonful of the first mixed with the same amount of glycerine, and then well shaken together with one pint of oil,[2] or saturated in carbolized vaseline, or in a strong solution of bicarbonate of soda. Lacking these, the spots may be covered with cream, dampened starch, or any substance that will exclude the air. When blisters form, their contents may be removed by slight punctures of a sharp needle.

2. In severe cases there is more or less shock, and it may be necessary to suspend local measures, and revive

[1] Kindling fires with kerosene oil, filling lamps when they are lighted, running or moving quickly while one's clothes are on fire, and working about open fires in loose cotton dresses, are all sources of danger.

[2] This mixture is much cleaner than many of the burn mixtures, and quiets pain. It should be kept on hand in houses and factories. In case olive oil cannot be obtained, similar oils will answer. Strips of cloth are to be preferred to large pieces, as they can be more readily removed. In burns from an acid, apply *first* lime-water or a solution of baking soda; if from an alkali, — as lye, — apply vinegar and water, one part vinegar to four parts water.

the patient by stimulants, as before directed in cases of shock.

3. Do not remove the dressings unless cleanliness demands it. When you do, use great gentleness, that you may not injure newly formed skin. Oily dressings should, from time to time, have fresh oil applied over them, and it is well to spray liquid dressings with a mixture of carbolic acid, one teaspoonful to one-half pint of water.

4. Troublesome, contracting scars, producing deformities, sometimes follow burns. Especially is this the case at the bend of a joint, or where the skin is loose, as about the eyes, mouth, and neck. In short, there is great responsibility involved in the care of burns and scalds, and no person should attempt their continued treatment, when a physician can be obtained.

415. **Frost Bite.** — This results from exposure to severe cold. The affected part, through reduced vitality, becomes bluish or white. Sometimes exposure to cold winds or a severe snowstorm will gradually produce a congestion of internal organs and a tendency to sleep, which, if indulged, especially in the open air, may result in death.

Treatment. To bring about reaction, place the person in a room without fire, and gradually rub the chilled or frozen parts with ice, snow, or cold water. Stimulants may be necessary. When the parts begin to redden and sting, or become painful, stop active treatment, for reaction has commenced, and care is necessary (by rest, sleep, and *gradually* increasing warmth) lest the returning circulation in the skin become too active, and so cause inflammation.

416. **Fractures and Dislocations.** —The signs of a fractured or broken bone are, generally, more or less change in the

shape and natural appearance of the injured part, pain and inability to move the part readily, tenderness and unnatural mobility at the point of injury, and a grating sound when the broken ends of the bone are gently rubbed against each other. The symptoms of dislocation, or bones out of joint, are, in general, a more marked deformity and more impaired motion than in the case of a fracture.

Treatment. There is generally but little urgency in the treatment of a broken limb. The common impression that a broken bone must be set immediately is erroneous, and tends to induce much handling of the injured parts. This is always dangerous, as jagged ends of bones may be made to injure the soft tissues. Put the patient in as comfortable a position as possible, pending the arrival of the surgeon. Support the affected part by pillows, blankets, shawls, or coats, so as to prevent the painful twitchings of the injured muscles, and to preserve, as nearly as possible, its natural shape. In case of fracture of the collar bone, place the forearm in a sling, improvised from a long towel or any piece of cloth, putting a soft pad in the armpit of the affected side; let the patient lie on his back, with a small pillow between his shoulders. If the patient is to be moved, steady the affected arm by a bandage over it and around the body. A broken arm is made most comfortable by placing it in a semi-flexed position upon a pillow; a broken leg, by gently extending it to its full length and supporting it by pads on both sides. With a broken knee cap, the leg should be elevated on an inclined plane, with a figure-of-8 bandage about the knee. If one or more of the ribs are broken, apply a bandage firmly around the chest, to prevent motion, so far as possible. When a jaw-bone is broken, hold the parts in proper place by a bandage about the head.

When the patient is to be removed, the necessary additional support to the broken bones may be obtained by binding on softly padded "splints," that is, shingles, pieces of leather, sticks, or anything that can serve to hold the bones quiet and, as nearly as possible, in normal position. The setting of a bone should be done by a surgeon. When once the injured parts are adjusted, they should not be disturbed.[1]

In a case of dislocation, the bystanders should merely make the sufferer as comfortable as possible. The reduction of a dislocation should never be attempted by a layman, if a surgeon can be obtained.

417. Sprains[2] are bruised or torn ligaments, cartilages, muscles, and nerves about the joints, and are serious injuries.

Treatment. After such an injury, though apparently slight, *rest is necessary*, and this may be temporarily obtained by firmly, but gently, wrapping the part in cloths or bandages dipped in hot or cold water, as the feelings of the person may indicate and the surround-

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[1] The process of repair in broken bones is similar to that witnessed in the healing of wounds of the soft parts. New, delicate material is abundantly deposited between and about the ends of the broken pieces. This gradually hardens to the consistency of bone, in the meantime decreasing in size, so that very little deformity results if the broken bones have been kept well in place. The best surgeons are at times unable to prevent deformities, owing to the impossibility, in certain instances, of securing the proper apposition and retention of the broken parts. An unprofessional person should not attempt to set a broken bone, if a surgeon can possibly be procured.

[2] The terms *sprain* and *strain* essentially apply to the same conditions, though *strain* is sometimes used as meaning merely the result of stretching of muscles.

ings admit. The surgeon may ultimately apply a proper splint.

418. **Contusions or Bruises** result from falls, blows, or pressure, and, if severe, are attended by shock, broken blood-vessels, and crushed muscles and other tissues. Black and blue spots, which result from the oozing of blood from injured blood-vessels, are largest where the tissues are lax and contain little fat, such as the connective tissue under the skin of the scalp and eyelids. They usually disappear after a few hours or days.

Treatment. Rest, relief from shock, the elevation of the bruised part so as to retard the flow of blood into it, and the application of cloths wet with hot or cold water.[1]

419. **Wounds** are generally classified as follows: —

Incised wounds (*i.e.* cuts or incisions of various depths, made generally by sharp instruments), *punctured wounds* (such as stabs, and pricks made by splinters, thorns, or needles), and *poisoned wounds* (such as the bites of snakes, spiders, or rabid dogs). If the wounded part is very much bruised, the wound is called a *contused wound.* If the skin and tissues beneath are much torn, it is a *lacerated wound.*

Wounds may be attended by more or less hemorrhage, by pain, and by the presence of dead or foreign matter, viz., fibres of cloth, dirt, or coagulated blood.

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[1] Hot water hastens most quickly the disappearance of black and blue spots, but cold water is also of value. Cloths may be wet in alcohol and water, equal parts, or in equal parts of alcohol, vinegar, and water, or in water to which has been added one-sixth part of tincture of arnica or extract of witch hazel. Water dressings, if continued too long, lower the vitality of the part, and should be replaced by a firm flannel bandage.

Treatment. Ascertain the source and amount of the bleeding, and do not be alarmed by the amount of the clothing stained, for a small amount of blood will often make a large stain, and yet the source of the bleeding may frequently be controlled with ease.[1] When the wound is located, the kind of hemorrhage will be apparent. If a large artery has been cut across, the blood spirts. If, from spontaneous coagulation, the blood has ceased to flow, it may be well not to disturb the condition of things, until removal of the patient to a better location; but remember that in the removal, if the person is jarred much, bleeding may recur, and will need to be checked. To stop external bleeding, *pressure is of the first importance*, then applications of ice, hot water, tannin, or alum. If the bleeding is comparatively slight, or occurs in places where the bones are near the surface, as in the scalp and face, pressure may be applied to the wound by the fingers, or by a pad held firmly in place by a bandage. If severe, and especially if from an artery, pressure must be applied between the wound and heart, by means of a pad bound over the main artery. In the case of a limb, it should be elevated, and the artery should be pressed upon above the wound, by a knot in a suspender or piece of cloth, which is first tied about the limb and then twisted by

[1] A surgeon relates the following: "Was called one night to see a woman, reported to be bleeding to death. Found her in a close room, sitting in a chair, with blood-stained carpet about her, and, wrapped around one of her legs, a sheet soaked in blood. Tearing this off, I found a little stream of blood trickling from a small opening in a blood-vessel, between the knee and the ankle. Pressure with the finger readily controlled the bleeding for the time, and a properly applied bandage accomplished the end afterward. Much anxiety, loss of blood, and injury to carpet might have been saved by a little coolness and knowledge."

means of a stick until the bleeding ceases.[1] This is called a tourniquet.

When the bleeding is controlled, carefully remove dirt or other foreign matter, and replace any organ which may protrude. Wash the wound and the parts about it with carbolic acid and water (one teaspoonful to a pint), containing a little glycerine, or with hot water, or with common salt and water, one tablespoonful of salt to a pint of water. The operator's hands should be cleansed previously with hot water and soap. These antiseptic precautions insure cleanliness and ward off dangers from bacteria.

After cleansing, dry the wound gently, and, if it is an incised one, bring its edges together by strips of surgeons' adhesive plaster, parallel to each other, and from one-half to one-fourth of an inch apart. Never cover the entire wound with plaster, as some exit must be allowed for any oozing that may occur. The tourniquet may now be removed, if the proceeding be not attended with renewed bleeding, and a pad and bandage of *clean*, dry cloth or of antiseptic gauze applied, to assist in keeping the strips of plaster in position and to prevent secondary bleeding.

If the wound is jagged and torn, so that the edges cannot be brought together, replace the parts as nearly as possible in their normal position. If there is a tendency to bleeding, apply firmly clean cloths wet with carbolized hot or cold water; if there is no such tendency, cleanse the wound, and apply dry dressing[2] with pressure.

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[1] The main artery of the arm runs along the inner edge of the prominent muscle which stands out when the arm is strongly bent; of the thigh, along its inner middle line. These arteries and other principal ones are outlined in Fig. 62.

[2] Dressings do not need to be removed for several days, unless they become foul.

420. *Punctured Wounds* are usually considered most dangerous, on account of the bruising which generally accompanies them, the injury to the deeper tissues, and the character of the sources of injury, — rusty nails, pieces of shell, needles, splinters of wood, etc. If in the sole of the foot or the palm of the hand, they may cause lockjaw, and are sometimes followed by erysipelas and other forms of inflammation; whereas, the principal danger from an incised wound is hemorrhage.

Treatment. If the sources of the injury are still in the wound, remove them. Thorns, needles, splinters, etc., should not be left in the body, with the idea that they will work their way out. Poking at them, however, as in the case of splinters, adds to the irritation already set up. If a splinter is under the finger or toe nail, and cannot be pulled out, scrape the nail thin over the splinter, until it can be easily cut and the splinter seized; or make an incision on each side of the foreign body, and remove the tongue of nail between. The skin and tissues of the palm and the sole are so firm and dense that imprisoned matters cannot easily find exit, and lockjaw may result. It is important, therefore, that an incision should be made over the foreign substances, so as to reach them easily and to allow a free exit for blood, etc. The removal of needles, unless they are near the surface, had better not be attempted by others than surgeons, as on being touched they readily slip between the fibres of muscles and connective tissues. If there is a tendency to such slipping, or if the needle seems deeply buried, hold the part still till the surgeon comes.

When a fish-hook enters a part, and does not go through, push the point through if possible, and then cut the barb off and withdraw the remnant. If the barb cannot be

pushed through, cut down upon the hook and remove it. In these wounds, carbolized water dressings (one teaspoonful to a pint of water) are best. Pain may be relieved by the addition of laudanum (one tablespoonful to a pint of water).

Poisoned Wounds will be considered under the head of poisons, p. 411.

421. Special Hemorrhages. — Of these, the most common and the least dangerous is bleeding from the nose. This results from falls, blows, or disease, or may be an effort of nature to relieve internal congestion. Often it is preceded by a feeling of weight, pain, and fulness about the forehead.

Treatment. Ascertain if the blood escapes from one or both nostrils, then raise the arm on the affected side above the head, compress the nostrils, and apply cold to the forehead or back of the neck. Frequently it is sufficient if the patient remains quietly in a sitting posture. If the bleeding continues and the person is faint, inject into the affected nostril a syringeful of ice-water or solution of common salt, or a weak solution of alum, or blow in some tannin. The nostrils may be plugged by cotton dipped in one of the above solutions. If blood still forces itself into the throat, and so out of the mouth, the case should be put in charge of a physician. In all forms of hemorrhage, the patient must be kept quiet in a cool room, and, when faint from severe bleeding, in a recumbent posture, with the head lower than the body. Bleeding in the mouth may be relieved by pressure, or by one of the above styptics. Blood coming from the stomach is usually dark in color, and mingled with food. From the lungs, the blood is bright red and frothy, mixed with bubbles of air, and

is generally accompanied by a cough. For relief, try quiet, a recumbent posture, ice and styptics internally, in small quantities, so as not to induce vomiting; cold may be applied over the region of the stomach. Bleeding from the gum, after the extraction of a tooth, is sometimes alarming; but continued pressure in the socket with the tip of the finger, or a piece of sponge, or a plug of wood held firmly in place by the jaws, is ordinarily sufficient. When pressure, cold, and ordinary styptics will not control hemorrhage, touching the bleeding spot with a red-hot knitting-needle is of service.

422. Foreign Bodies. — Pieces of bone, meat or other food, pins, false teeth, etc., sometimes lodge in the larynx, causing great difficulty in swallowing and breathing, and give rise to the feeling and danger of suffocation.

Treatment. A sharp blow upon the back, if given immediately after the accident has occurred, will sometimes assist the patient to eject the foreign body. If it fails, invert the patient, and move him from side to side, while some one strikes him between the shoulders with the open hand; or lay him on chairs, bed, or table, with the head and upper part of the chest hanging over, and make sudden pressure on the back when he breathes out. If this fails, and the foreign body cannot be dislodged by the finger introduced into the mouth, the surgeon is needed.

Little children sometimes put peas, beans, shoe-buttons, pins, etc., into the nose or ears. Insects also enter these places. Small bodies may be removed from the ear by syringing with tepid water, the nozzle of the syringe being placed against the upper wall of the ear canal, and the auricle pulled upward and backward. Larger bodies may be gently scooped out by a bent probe or

the rounded end of a hair-pin, care being taken not to injure the drum membrane. Insects may be washed out, after being smothered with salt water or oil. If the foreign body is in the nose, close both nostrils, take a full breath through the mouth, and then breathe out suddenly and forcibly through the affected nostril. Sometimes sneezing, induced by snuff, will dislodge it.

Foreign bodies in the eye, if not removed promptly, cause serious inflammation. Never rub the eye to dislodge them; gently use a moist camel's-hair brush, or a piece of wet cotton wrapped around a very small, smooth piece of wood. Particles of steel or iron may be removed by a magnet. Sometimes it is difficult to see a minute particle, unless a bright light falls directly upon the eye. The best position for the operator is to stand behind the chair of the patient, or a little to one side, steady the affected eye, and keep the lids open with the fingers of the left hand; or, sitting in front of the patient, turn the upper lid gently backward, over a lead-pencil, penholder, or firm toothpick. The lower lid is readily everted. A magnifying glass is of service, in detecting whether a supposed particle is one in reality, or merely a stain from a piece of metal, or a natural discoloration. Eyestones are sometimes used to dislodge particles from under the eyelids; but it is much better for the patient to take hold of the lashes of the upper lid, raise it from the eyeball, and then move it firmly but gently over the lower lid toward the inner corner of the eye. The inflamed condition of the eye, after a foreign body has been in it, is generally relieved by a drop of olive oil or castor oil upon the eye, or by a gentle bathing with hot water. Poultices or patented eye-washes should not be used. If the foreign matter is lime, bathe the eye with a weak solution of vinegar and water.

Poisons.

423. Poisons may be classified as *irritant*, *narcotic*, and *acro-narcotic*. The first act *locally*, upon the skin, air passages, lungs, and alimentary canal. They cause pain and inflammation, and may produce vomiting, or difficulty in breathing or in swallowing. Substances whose local action is very destructive are called corrosive poisons. Irritant poisons include metallic poisons, such as copper and mercury; irritating gases; and vegetable and animal substances, such as cantharides, decayed meat, and poisonous fish. The corrosive group comprises the strong acids, such as sulphuric, nitric, muriatic, and oxalic; and alkalies, such as potash and ammonia, acid and alkaline salts, and corrosive sublimate.

Narcotic poisons act *remotely*, *i.e.* through the blood and nervous system, and produce delirium, convulsions, stupor, or marked prostration. They include such substances as opium, chloral, alcohol, belladonna, and aconite. Acro-narcotic poisons act both locally and remotely. They include pinkroot, ergot, lobelia, etc., and the poisons in venomous bites and stings and virulent wounds.[1]

Symptoms. Usually we suspect poisoning if a person is taken *suddenly and violently ill*, especially if there is great

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[1] A popular idea is that a poison is a substance which, taken in small amount, will destroy life. The fact is, there are varying degrees of susceptibility to the action of a poisonous substance, and by the habitual use of a substance large doses may often be taken with impunity. Some persons are so susceptible that they cannot take even the most minute dose of calomel without a resulting sore mouth, or of belladonna, without its producing a dry throat and dilated pupils. Of the lower animals, hogs, it is said, can eat henbane with impunity; pheasants, stramonium; goats, tobacco and water hemlock.

pain and repeated or severe retching or vomiting, and if it is known that the person has recently taken food or drink.[1] It sometimes happens that severe colic from undigested food, an attack of cholera morbus, the pain and distress referable to heart disease, or the stupor due to apoplexy are mistaken by the ignorant for symptoms of poisoning, and the patient is roughly and wrongly dealt with. To ascertain whether a person has been poisoned, carefully examine the mouth, lips, and breath; search the clothing and the room in which the poison is supposed to be. A person who has taken poison with intent to kill is likely to prevaricate and destroy the evidence of the poison used.

Spasms, with more or less unconsciousness, indicate strychnine; quiet, deep sleep, from which a person is not easily aroused, and strongly contracted pupils indicate opium; stupor, with salivation, indicates mercury; inflammation of the mouth, severe pain, retching, and vomiting indicate arsenic or other corrosive poison; delirium indicates belladonna, stramonium, or hyoscyamus; unusual excitement, with occasional stupor, indicates alcohol or Indian hemp; loss of muscular power, feeble pulse, great prostration, paleness, and coldness of the skin indicate tobacco, aconite, or digitalis; bloated and livid face,

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[1] Poison may do its work slowly, if taken in small amount and repeatedly, and the patient may be thought to have a chronic disease. Such poisons are called *cumulative*. Lead and arsenic are examples.

Drugs and medicines containing poisonous ingredients, as chloroform, opium, belladonna, fusel oil, etc., should not be left within the reach of little children or others likely to use them recklessly or without cause. Such things should be in bottles of a peculiar shape, and with peculiar colored labels. There is a great danger (which is constantly increasing) in the indiscriminate use of powerful medicines without the advice of a physician.

limbs contracted, and head thrown back indicate the suffocative gases.[1]

Treatment. In most cases of poisoning, we are to endeavor: 1. To get the poison out of the body, by encouraging vomiting. 2. To neutralize, or render inert, by means of antidotes, what cannot be removed. These act mechanically, chemically, and by reason of their physiological properties. 3. To combat any dangerous symptoms that have arisen, and to obviate their effects by means of stimulants, artificial respiration, and by exciting the action of the skin, kidneys, and bowels.

First, to remove the poison as quickly as possible from the body, emetics should be given. Give at least every *fifteen minutes*, until vomiting is produced, copious draughts of warm water or other drinks, or one pint of warm water with a teaspoonful of mustard,[2] well stirred in. Tickling the throat with a feather assists the act of vomiting. If the person will not swallow readily, close the nostrils with the thumb and finger, while the emetic is given. If necessary, pry the mouth open, depressing the tongue with the handle of a strong spoon, a clothespin, or a stick. By pressing on the jaws at their joints, the mouth will be forced open.

Second, to neutralize or render inert what cannot be removed, antidotes should be given. Examples of chemical neutralizing substances are weak acids (lemon juice or diluted vinegar), to be used when the poisons are such

[1] Alcoholics may hide the common symptoms of poisoning. The profound sleep of some intoxicated persons resembles closely the sleep produced by opium.

[2] The mustard should be thoroughly mixed with the water, lest some of it may cling to the lining of the stomach and excite inflammation. The stomach pump should be used by physicians only.

alkalies as lime, potash, etc.; and, on the other hand, alkalies, such as lime-water, weak soda-water, and soapsuds, to neutralize acid poisoning. Common salt, with milk and the white of an egg, should be opposed to nitrate of silver, verdigris, and corrosive sublimate. A fresh preparation of iron, formed by precipitating tincture of chloride of iron with a larger amount of ammonia, is an antidote for arsenic and metallic poisons generally. Belladonna is an example of a physiological antidote. It dilates the pupil of the eye, in opposition to opium, which contracts it. Coffee is a valuable physiological antidote to opium, its tendency being to excite, and to overcome stupefaction. Mechanical antidotes, *i.e.* such as allay irritation, are olive oil, milk, flour and water (in a thin paste), chalk mixtures, castor oil, mucilage, flaxseed tea, the white of egg and water, and, in case of strychnine poisoning, charcoal mingled with water. They serve to coat over the irritated mucous membrane, and thus protect it.

Specific Poisons.

IRRITANT AND CORROSIVE POISONS.

424. If the poison taken is *known* to be a corrosive one, omit emetics, and give antidotes immediately.

1. **Acids.** — *Sulphuric* (oil of vitriol), *nitric* (aqua fortis), *hydrochloric* or *muriatic*, *oxalic*, *carbolic*,[1] *acetic*, etc. The first three of the above are much used in certain factories, photographing establishments, etc., and are sometimes left carelessly about. Oxalic acid (frequently used to polish

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[1] Carbolic acid, so called, is not properly an acid.

kitchen boilers) is sometimes taken by mistake for Epsom salts, which it resembles in appearance.

Antidotes. Baking soda, borax, chalk, magnesia, wall plaster, or saleratus, mixed with water; lime-water; soap-suds; oil in large amount; followed by mucilaginous drinks, and stimulants, if necessary. When sulphuric acid has been taken, it should be quickly diluted by a free use of ice water.

2. **Alkalies and their Salts.**—*Soda; ammonia* (water of ammonia, muriate of ammonia, or sal ammoniac); *potassa* (caustic potash in sticks and lumps) has been mistaken by children for candy; *lye; liquor potassae*, a clear, liquid medicine; *pearlash*, or *carbonate of potash; nitrate of potash*, or *saltpetre*, used in corning beef, has been mistaken for purgative salts; *chlorate of potash*, a common remedy for sore throat, has been used unwittingly in large and poisonous doses; *binoxalate of potash* has been taken by mistake for cream of tartar.

Antidotes. Vegetable acids, such as vinegar, lemon juice, citric and tartaric acid in solution; fixed oils,—castor, linseed, olive, cod-liver, machine,—which form soaps and so prevent caustic effects; mucilaginous drinks, especially when saltpetre has been taken.

3. **Metallic Substances.** — *Antimony.* In tartar emetic and wine of antimony; an ingredient of pewter, Britannia, and type metal; oxide of antimony.

Antidotes. Assist the distressing vomiting by draughts of tepid water, flaxseed tea, or sugar water; give a cup of strong, green tea.

Arsenic. An ingredient of paris green (used to destroy insects among plants); of orpiment, a yellow paint; of real-

gar, a red paint; of arsenite of copper, or Scheele's green; used in some brightly colored artificial flowers, wall papers, candy boxes, and kindergarten papers; in fly powders, rat pastes; in the stuffing of birds; by enamellers; and in a number of medicinal preparations. Arsenic, as ordinarily obtained in the shops, is a fine, white powder, and may be mistaken for sugar or some equally harmless substance.

Antidotes. Freshly prepared oxide of iron (to be obtained at a drug store); give one teaspoonful every few minutes. Dialyzed iron, moistened charcoal, plaster, and calcined magnesia are other antidotes. Encourage vomiting. Allay irritation.

Copper. Found in some cooking utensils; in the alloys, bronze, brass, bell metal, german silver, etc.; in sulphate of copper, or blue vitriol; in acetate of copper, or verdigris. Poisoning has occurred from pickles made green by copper; from the use of colored confectionery; from the wrappers of farinaceous foods; from inferior filling for the teeth; and, in the workshops of some trades, from copper dust.

Antidotes. Milk; white of eggs; a quarter-teaspoonful of baking soda in water, every five minutes for half an hour. Allay irritation.

Iodine. Ordinary tincture of iodine; in some liniments.

Antidotes. Boiled starch and water; boiled or baked potatoes.

Iron. Copperas, green vitriol, or sulphate of iron, used in lotions and as a disinfectant.

Antidotes. Baking soda and mucilaginous drinks.

Lead. In the acetate or sugar of lead, often used as an application to sores or as an eye-wash[1]; in white lead and red oxide used by painters; in some hair-dyes; in water kept in leaden vessels or pipes; in wines sweetened by lead; in tin foil covering of tobacco and farinaceous foods; in pickle jars with metal tops; in newly painted rooms. It sometimes poisons the makers and users of glazed cards, japan ware, cosmetics, lead type, or tin spoons.

Antidotes. Strong solution of Epsom or Glauber's salts, or emetics.

Mercury. Bichloride of mercury, or corrosive sublimate, used in solution as a medicine, as an ingredient of lotions, and for the destruction of vermin; in red oxide, or red precipitate, and the white precipitate upon looking-glasses; in the preservation of stuffed birds and animals. It is corrosive.

Antidotes. White of eggs; flour beaten up with milk and water.

Phosphorus. An ingredient of many rat poisons. Children have been poisoned by eating these, and by sucking matches. The vapor in match factories is a source of poison.

Antidotes. Large quantities of magnesia or chalk in water; plaster; milk of magnesia; white of eggs. *Avoid fatty substances.*

Silver. Lunar caustic or nitrate of silver, an ingredient of hair-dyes; used in solution as a lotion; some forms used in photography and the trades.

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[1] Eye-washes containing lead are apt to cause opacity of the eye.

Antidotes. One to two teaspoonfuls of salt in a tumbler of water decomposes the poison and arrests its activity. Allay irritation.

Tin. In some dyeing substances; in poor cans for the preservation of food.

Antidotes. See "Copper," p. 406.

Zinc. Sulphate of zinc or white vitriol, used in lotions; chloride of zinc in disinfectants.

Antidotes. Bicarbonate of soda in water; milk and white of eggs. Vomiting relieved by copious draughts of warm water.

4. **Gases.** — *Chlorine*, a suffocative gas, used in trades and chemical experiments; *carbonic oxide* (stove gas), from incomplete combustion in stoves and furnaces; *carbon dioxide* (choke damp), in deep wells, cisterns, vats, closed cellars, mines, sewers, etc.; *sulphuretted hydrogen* (odor of decaying eggs), a subtle poison, found wherever there is putrefaction, in cesspools, sewers, and outhouses; *illuminating gas*, etc.

Antidotes. Fresh, pure air; dashes of cold water upon the face; inhalation of vapor of ammonia; artificial respiration.

5. **Animal and Vegetable Poisons.** — *Poisonous fish:* conger-eel, bladder fish, gray snapper, etc.; some shell-fish.

Antidotes. Emetics; emollients; strong purgatives; stimulants.

Croton oil, a violent purgative, also used in liniments, may be mistaken for a harmless oil; *poke berries; oil of tansy; beans of castor-oil plant; wild parsnip; oleander;*

marsh marigold; cantharides, or Spanish Fly; *colchicum*, used frequently in rheumatic medicines, etc.

Antidotes. After vomiting, give strong coffee, or vinegar and water; mucilaginous drinks; stimulants.

NARCOTIC POISONS.

425. Opium, in laudanum, paregoric, cordials, powders, many liniments, soothing syrups, cholera mixtures, etc., is a particularly active poison in the very young and the old.

Antidotes. Strong coffee; aromatic spirits of ammonia (fifteen drops every fifteen minutes till the patient recovers); electricity; cold douches; slapping of the surface by hands or wet towels. *Keep the patient moving if inclined to sleep, and, if possible, in the open air.*

Belladonna (deadly nightshade) in ointments, liniments, and lotions. Its active principle, atropia, is used in solution by oculists as an application to the eye. The leaves and berries of the plant are sometimes eaten by children.

Antidotes. Cold douches; brandy; paregoric, fifteen drops, or laudanum, five drops, *with care*, every quarter of an hour, with large doses of lime-water; electricity.

Hemlock. — Five varieties are said to be poisonous, and all parts of the plant. The roots of the water hemlock are sometimes mistaken for parsnips. One variety (fool's parsley) is sometimes mistaken for ordinary parsley. The hemlock is common, and grows in hedges and wild places.

Antidotes. Aromatic spirits of ammonia. If much pain and vomiting, ten grains of bromide of potassium every half-hour or hour, as the case demands.

Stramonium (thorn-apple, Jimson or Jamestown weed). — Found along roadsides, and near fences in out-of-the-way places. Blossoms, capsules, and seeds are poisonous, if eaten.

Antidotes. Same as for Belladonna, p. 409.

Strychnine, as sold in the shops, is a white powder; bought frequently to poison animals; is an ingredient of tincture of nux vomica.

Antidotes. Chloroform, or ether, inhaled to relieve spasm; cold douches; aromatic ammonia; camphor spirits; bromide of sodium, five grains every half hour; rectal injection of an infusion of tobacco; artificial respiration.

Prussic Acid. — Hydrocyanic acid, used in a dilute form, medicinally; cyanide of potassium, used to kill moths, butterflies, etc.; in laurel water; the meat of peach, cherry, plum, and almond pits, if freely eaten.

Antidotes. See "Gases," page 408.

Chloroform and Chloral, both too often used indiscriminately and recklessly by people at large.

Antidotes. Slapping of body, cold douches, stimulants, electricity, artificial respiration.

Digitalis (foxglove), a garden plant. Its extract used medicinally.

Antidotes. Same as for Belladonna, p. 409.

Hyoscyamus (henbane), used medicinally.

Antidotes. Same as for Belladonna, p. 409.

Alcohol, used repeatedly, even in the so-called moderate amount, is sometimes a slow poison. In larger amount, especially in the young or feeble, it has caused acute

poisoning, and even death. Wood spirits, *i.e.* wood alcohol, used as a solvent of gum, and sometimes in liniments, is more poisonous, if taken internally, than ordinary alcohol.

Antidotes. In acute poisoning, emetics, cold douches, coffee, aromatic spirits of ammonia, and slapping the soles of the feet.

ACRO-NARCOTIC POISONS.

426. Venomous Bites and Stings. — *Treatment.* In case of snake bite, or that of an animal supposed to be mad, tie a string or handkerchief tightly about the limb just above the bite; then suck the wound, or encourage the blood to flow by means of a cupping-glass. Wash out the wound with warm water and rub thoroughly into it a piece of nitrate of silver, or paint it with undiluted carbolic acid, or press into it, for a moment, the end of a red-hot knitting-needle. When poisoned by a snake, use alcoholic stimulants freely. Sometimes the bite of a human being is very dangerous.

When stung by bees, wasps, scorpions, etc., extract the "stinger" by fingers, small forceps, or pressing about it with the barrel end of a watch key; then apply spirits of ammonia, saleratus water, or mud.

Poisoned Wounds; Infectious Diseases. — The contact of the skin (especially if it is broken) with decomposing substances, poisonous cards, utensils, etc., or of the mucous membrane with matter secreted from diseased surfaces, has produced diseases from which persons have died.

Treatment: Stimulants internally, and mild applications externally, *till the doctor comes.*

POISONOUS PLANTS.[1]

427. Fatal cases of poisoning are usually among children, in the spring of the year, when they search for green things, and too frequently "dare" each other to eat of plants they find. Conium is mistaken for sweet cicely, poke roots for artichokes, blue flag for sweet flag, kalmia leaves for wintergreen, and hellebore for marsh marigold. Children should be taught the difference between poisonous and non-poisonous plants.

Water Hemlock.[2] — Every part is poisonous, if eaten, especially the root; grows in lowlands, and resembles parsley.

Poison Hemlock (Conium). — Seeds mistaken for anise; root poisonous if eaten, especially in late spring.

Black Nightshade. — Clusters of white flowers, followed by black, round berries; should not be eaten; neither should the red berries of the *bitter-sweet.*

Coke, or Scoke. — The root is poisonous, if eaten.

The Lobelias are poisonous; viz., the *cardinal flower* with tall spike of red flowers, the *large lobelia* with blue blossoms, and *Indian tobacco.*

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[1] Most of these act both as irritants and narcotics, but the narcotic effect depends largely on the amount absorbed by the skin or mucous membrane.

For stramonium, hemlock, and belladonna, see narcotic poisons.

[2] Cowbane, spotted parsley, muskrat weed, beaver poison, and wild --snip are common names for water hemlock.

Toadstools. — Three varieties are particularly poisonous. Sometimes mistaken for edible mushrooms.

Mushrooms. — Poisonous mushrooms, according to Christison, are recognized by their dark color; acrid, bitter taste; pungent odor; and by the fact that they generally grow in dark, damp places.[1] The edible have gills at first delicate pink, afterward purple and tawny black; stem white, full, firm, varying in shape, *with a white, persistent* ring. They must be sought for in the open fields. The best kinds have a peculiar, easily recognized odor.

Aconite (monkshood, wolfsbane). — Preparations of leaves and roots are used medicinally, internally, and in liniments. Preparations of the root are several times stronger than those of the leaves. The plant has been mistaken for the horse-radish. This poison produces peculiar numbness, or tingling sensations in the mouth, throat, and skin.

Mezereon. — A garden shrub having bright red berries, sometimes eaten by mistake for currants.

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[1] "On the subject of distinguishing poisonous species, Mr. Cooke says that there is no golden rule which will enable us to tell at a glance the good species from the bad. The only safe guide lies in mastering, one by one, the specific distinctions, and increasing the knowledge through experience, as a child learns to distinguish a filbert from an acorn, or a leaf of sorrel from one of white clover. The characters of half a dozen good, esculent species, he says, may be learned as easily as the ploughboy learns to discriminate as many species of birds. He tells us, moreover, that it is not enough to avoid poisonous species, but that discretion should be used in preparing and eating good ones. They change so rapidly that even the cultivated mushroom, if long kept, is unfit for use. Nor is it enough that they be of good species and fresh; but plenty of salt must be used in their preparation, to neutralize any deleterious property, and pepper and vinegar are also recommended as advantageous." — *Popular Science Monthly.*

Spurred Rye, or Ergot.—In medicines; sometimes carelessly ground with rye into flour.

Poison Sumac ("poison dogwood," "poison elder") is between a shrub and a tree, found in moist places; all of its parts are poisonous.[1]

Fruits.—Do not eat berries of the bitter-sweet, black nightshade, buckthorn, poke, baneberry, leather wood, yews, juniper, red elderberry, privet, English ivy, wahoo, or daphne.

Seeds.—Do not eat the seeds of stramonium, corn-cockle, castor-oil plant, black cherry, foxglove, saffron, or mullein, or the common horse-chestnut, or red buckeye.

Flowers.—Do not eat those of stramonium, laurel, stagger-bush, elder, locust, or lily of the valley.

Treatment for above Acro-narcotic Poisons.—Allay irritation by drinking milk, olive oil, mucilage, etc. Overcome narcotic effects by fresh air, stimulants, cold douches, electricity, artificial respiration.

428. Certain plants are *poisonous to the touch*, some persons being more susceptible than others.

The Poison Ivy is very common, grows along the ground, or clings to stones, stumps, fences, or trees. It is distinguished from the harmless woodbine or Virginia

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[1] For further information as to poisonous plants, see Report of New Jersey Agricultural Experiment Stations, Bulletin No. 135, and "Principal Poisonous Plants of the United States," Bulletin No. 20, Department of griculture, Division of Botany.

creeper, which often grows with it, by having *three leaflets* together, instead of five, as has the latter vine. All parts of the plant are poisonous, especially its juice. Thick gloves should be worn when working where it is.

Treatment. Wash poisoned spot with alcohol and water, then keep applied cloths saturated with lime water, buttermilk, a strong solution of sulphite of soda, or iodide of potassium.

Poison Dogwood is more poisonous to many persons than poison ivy. Treatment same as for ivy poison.

The Stramonium Plant, when touched, sometimes inflames the skin. Treatment same as for ivy poison.

APPENDIX.

References are to page and section of text. In the text, reference to these notes is made by letters.

PAGE **11**, § 11 (*a*). **Divine and Wholesome Discontent.** — "I would make men and women discontented, with the divine and wholesome discontent, at their own physical frame and at that of their children. I would accustom their eyes to those precious heirlooms of the human race, the statues of the old Greeks; to their tender grandeur, their chaste healthfulness, their unconscious, because perfect, might; and say, — There; these are tokens to you, and to all generations yet unborn, of what man could be once; of what he can be again if he will obey those laws of nature which are the voice of God. I would make them discontented with the ugliness and closeness of their dwellings; I would make the men discontented with the fashion of their garments, and still more just now the women, of all ranks, with the fashion of theirs; and with everything around them which they have the power of improving, if it be at all ungraceful, superfluous, tawdry, ridiculous, unwholesome." — CANON CHARLES KINGSLEY, *Health and Education.*

PAGE **11**, § 11 (*b*). **Deaths in Armies, in War Times, from Sickness and Wounds.** — "The losses through sickness in war times are great, even in temperate climates. During the Crimean War, when the Anglo-Franco-Sardinian forces reached the total of 428,000 men, there were 362,000 sick, 69,200 of whom died. Only 6200 soldiers died from wounds. In the Franco-German War of 1870–71, out of 200,000 Germans surrounding Metz, 130,000 were in hospitals; and out of a total number of 295,000 sick men taken care of in German hospitals, only 88,000 were there on account of wounds received on the battle-field. The total number of German soldiers sick or wounded amounted to 812,000 men. According to the statistics of the American Civil War, the number who were killed in battle and died from wounds was 93,969. Those who died from disease numbered 186,216." The deaths reported in the Spanish-American

War, among United States soldiers, from May 1, 1898, to April 30, 1899, was 6406. Of these, 5438 were from disease; 968 soldiers were killed in battle, or died of wounds, injuries, and accidents.

PAGE **43**, § 37 (*a*). **Habits of Posture modify the Shape.** — "Every occupation presents temptations to the body to acquire a habit of posture which, in time, modifies the shape of the individual. . . . The woman who sews by hand acquires a low right shoulder; while the one who habitually uses a machine, upon which both arms rest, tends to become high-shouldered with symmetrical body lines. The man who stands at a desk with arms supported, in time assumes the same shape. The sailor who climbs the masts, acquires a similar shape, although in a different way. The man of letters, with head forward and chin depressed, elongates his cervico-occipital muscles, so that at middle life we recognize him without difficulty. The drug and dry goods clerk, if right-handed, works with left foot thrown to the side and body to the right; both arms in front of the hip line. The resultant shape we are all familiar with, if at all observant. The horse-car driver, as he stands with his right hand on the brake and left on the dash-board, acquires a "left foot twist" in accordance with this posture. The truck-driver, who sits with arms forward holding his reins, is a characteristic figure. The man who digs the street, the bricklayer, and the hod-carrier all assume, in time, their own trade-mark." — PROF. ELIZA M. MOSHER, *The Influence of Habitual Posture on the Symmetry and Health of the Body.*

PAGE **54**, § 48 (*a*). **The Human Hand.** — "We ought to define the hand as belonging exclusively to man, corresponding in sensibility and motion with that ingenuity which converts the being who is the weakest in natural defence to the ruler over animate and inanimate nature. . . . As Galen long since observed. 'Did man possess the natural armor of the brutes, he would no longer work as an artificer, nor protect himself with a breastplate, nor fashion a sword or spear, nor invent a bridle to mount the horse and hunt the lion; neither could he follow the arts of peace, construct the pipe and lyre, erect houses, place altars, inscribe laws, and, through letters, hold communication with the wisdom of antiquity.' But the hand is not a distinct instrument; nor is it properly a superadded part. The whole frame must conform to the hand, and act with reference to it." — DR. BELL, *The Hand.*

PAGE **57**, § 51 (*a*). **Importance of Conjoint Action of Muscles.** — "The state of equilibration between the muscles performing opposite kinds of movements . . . may be readily illustrated by the part played

by the muscles placed before and behind the spine, in maintaining the erect posture of the body. The position is kept up without effort, without even consciousness, by the healthy man whose muscles are well balanced and in good 'tone.' It may be, however, that the same man, after a long day's work over a desk in an ill-ventilated city office, no longer presents that supreme unconsciousness of his muscles and their action, and the stoop of his shoulders and bent head demonstrate to others that the balance is no longer kept, that the tonicity of the morning has passed off, and the wearied muscles are no longer on the watch. And so it is when, in sleep, the muscles are relaxed and gravity asserts its force, so that the head falls forward by its own weight, no longer restrained by the passive counteraction of its 'extensor' muscles. . . . So little is the effort required to keep the body erect, that it is a sign rather of weakness than strength in any one who exercises an effort to do this. This may seem paradoxical, but it is nevertheless the case; and he who walks 'bolt upright,' with his chin in the air and his back as rigid as a plank, is often not a strong, but a weak man." — Dr. Sidney Coupland, *Personal Appearances* (*Health Primer*).

Page **63**, § 58 (*a*). **Time to be allotted to Sleep.** — "Where attempts have been made by literary characters to assign a proper period for sleep, they have either been guided by their known capabilities, or by what they have esteemed themselves capable of effecting; or they have been led, in their ignorance of physiology, into Utopian considerations regarding the time *wasted*, as they conceive, in rest. How else can we account for the idea of Jeremy Taylor, that three hours only in the twenty-four should be devoted to sleep? In an equally arbitrary manner, Baxter fixes on four hours, Wesley on six, and Lord Coke on seven. So much depends on the constitution and habits of individuals, that if some were restricted to the period allotted to Baxter, or Taylor especially, their lives could not fail to pay the forfeit. Men of active minds, whose attention is engaged in a series of interesting employments, sleep much less than the lazy and listless. It is probable that, in these cases, sleep is more intense." — Dr. Robley Dunglison, *Human Health.*

Page **69**, § 62 (*a*). **The Value of Physical Education to Students.** — Professor Edward Hitchcock says of the work accomplished at Amherst College: "From the beginning of the existence of the department of physical education in Amherst College it has never been the desire to develop the muscular system at the expense of any other part of the body,

as is too often understood to be the meaning of physical education or training. This department was not created, nor has it been developed, for the purpose of extraordinary attention to the muscular system. Its sole object has been to keep the bodily health up to the normal standard, so that the mind may accomplish the most work, and to preserve the bodily powers in full activity for both the daily duties of college and the promised labor of a long life. Indeed, in that particular, the precept of Cicero has been literally followed, namely, that bodily exercise should have for its chief object the development of a capacity for rational work. At the same time, it has been equally desired that the so-called exercises of this department should be mentally as well as physically enjoyed by the students, and not be made a tedious, mechanical, or heavy drill. . . . The results accomplished by this department in Amherst College lead its government to continue its existence, and sustain it on a par with the others."

Dr. D. A. Sargent, Professor of Physical Training at Harvard, in a paper read before the American Public Health Association, says: "Students enter college trained in mind but not in body; and where one fails for want of mental ability, ten break down for want of physical stamina. Many are short in stature for their age, or tall and slender, with a deficiency of muscular strength. Under an appropriate system of physical training, however, they make most rapid advancement, showing that their bodies had been kept in arrears, while their brains were developed. Many are ignorant of the first principles of physiology and hygiene, and leave school with acquired defects which are past remedying, but which a little appropriate knowledge and training could have obviated. Not infrequently the students who stood the highest in the preparatory schools are taken with a sort of mental dyspepsia after entering college, and devote most of their energies to physical exercises. This is invariably the case where the preparatory training has been forced and unnatural."

Page **69**, § 63 (*a*). **Cramp and Palsy from Overuse of One Set of Muscles.** — A form of palsy, sometimes known as hammer palsy, occurs from the continuous use of the hammer in scissors-making and forging of knife-blades, 100 blows, it is said, being necessary to forge one blade. In one day a good operator will make 24 dozen blades. "Tailor's palsy," "milker's cramp," and "writer's cramp" are instances of the overuse of certain muscles. In regard to "writer's cramp," Dr. George M. Beard states, after an examination of 125 cases, that "it is far less likely to occur in those who do original work, as authors, journalists, composers, than in those who do routine work, as clerks, book-keepers, copyists, agents, etc."

PAGE **70**, § 64 (*a*). **Some of the Results of Improper Muscular Exercise.** — "Every year a number of middle-aged men, who for years or months have been engaged in the sedentary occupation of a profession, of literature, or of business, at the commencement of the autumn holidays start for the Continent or the Highlands, and suddenly undertake immense fatigue in the ascent of Alpine heights, or the no less laborious work of a day on the moors, without the least preparation. So also we see, every bank holiday, crowds of young men starting off for some tremendous walk, or 'bucket' up the river, utterly unprepared for the task they undertake. Is it to be wondered at that men return complaining that their holiday has done them no good; that, instead of vigor, they complain of exhaustion; that their appetite fails them, their nights are sleepless, their limbs ache, and they are jaded and spiritless? It is the evils produced from this erratic athleticism that give rise to the formidable indictments that from time to time have been urged against vigorous exercise and the pursuit of manly sports, which, if properly managed and undertaken systematically, are really the foundation of really healthy life." — DR. C. H. RALFE, *Exercise and Training* (*Health Primer*).

PAGE **72**, § 67 (*a*). **Why Young Women should have Muscular Exercise.** — "It has been my privilege, for more than twenty-five years, to be intimately associated with young women, either as teacher in the schoolroom in the earlier years, or as medical practitioner, or teacher of hygiene, during the latter ones, and every day's added experience only confirms me in the position I have occupied from the first relative to the various forms of nervousness which characterize our sex. That position affirms that the best possible balance for a weak nervous system is a *well-developed muscular system.* Weak, shaky, hysterical nerves always accompany soft, flabby muscles; and it is a mournful fact that the *majority of the young women* whom I meet in schools are notably deficient in muscular development." — DR. MARY J. STUDLEY.

PAGE **72**, § 67 (*b*). **Housework as Exercise.** — Too many housekeepers believe that their indoor work affords sufficient exercise for them. Undoubtedly housework, if conscientiously performed, does exercise nearly all the muscles of the body. But it should not take the place of brisk, daily out-door walking, with its consequent inhalation of fresh air and thorough expansion of the lungs. It has been estimated that proper exercise for women should be equal to a walk of six miles per day. Average housework exerts as much muscular force as would be expended in walking two and a half miles, thus leaving a margin of three

and a half miles for the daily walk. English women frequently walk eight to nine miles. Unfortunately, some housekeepers endeavor to do more daily work than a walk of eight to nine miles per day would represent. They seldom go into the open air or take any other recreation, and sooner or later break down.

PAGE **73**, § 69 (*a*). **Kinds of Exercise.**

GOOD EFFECTS OF CERTAIN FORMS OF EXERCISE. — "Dancing is a cheerful and useful exercise, but has the disadvantage of being used within doors, in confined air, and often in dusty rooms and at most unseasonable hours. Practised in the open air, and in the daytime, as is common in France, dancing is certainly an invigorating pastime; but in heated rooms, and at late hours, it is the reverse, as these do more harm than can be compensated by the healthful exercise of the dance." — DR. COMBE.

"Five minutes of pretty brisk exercise on the bars, or with dumb-bells, or in any other moderate way, repeated several times during the morning, will have a wonderfully good effect in promoting full respiration, purifying the blood, and in nourishing the muscular system. The writer often picks up a chair, or any other moderate weight at hand, and after five minutes' play therewith, over the head or otherwise, can feel that the muscles of the arm have in that short time secured an extra supply of blood, which tends at once to nourish them, and to diffuse and equalize the circulation." — DR. RICHARD McSHERRY, *Popular Science Monthly*.

"It is surprising how short a period of vigorous exercise, daily, will develop an approach to the maximum of muscular power. . . . I believe that one hour a day of vigorous exercise, with proper attention to diet, will efficiently train a well-formed and healthy man for any reasonable feat of strength or endurance." — DR. AUSTIN FLINT, JR., *The Source of Muscular Power*.

BICYCLE RIDING. — "The bicycle as a means of training the body in habits of correct poise, and of strengthening the holding power of muscles, is a force the value of which can scarcely be overestimated. Like all good things, however, it must be used with discretion, if it is to do the good work for mankind which it so richly promises. The upright posture on the bicycle offers to the body exhilarating exercise with every organ and most of the muscles *in normal position*, and with an expenditure of force within the limits of ordinarily healthy individuals; the stooping posture, fast riding, and long hill climbing should of course be avoided." — PROF. ELIZA M. MOSHER.

BICYCLE RIDING VS. HORSEBACK RIDING. — "Bicycle riding has certain advantages over the present style of horseback riding. . . . When women

get into the habit of riding part of the time with the stirrup on the right side and part with the stirrup on the left, one objection to the spinal rotation and the unsymmetrical development will be overcome, and it is to be presumed that eventually they will all ride astride as their great-grandmothers did before the days of Elizabeth. The expense (of horseback riding) precludes this form of exercise for most women. Cheapness, safety, accessibility, and the small amount of preparation required are all on the side of the wheel." — DR. R. L. DICKINSON.

PAGE **77**, § 75 (*a*). **Strength and Elasticity of Skin.** — The strength of the connective tissue of the skin is best illustrated by the tension it will bear without breaking, as seen in one of the rites followed among Indians in testing the bravery and endurance of candidates who aspire to be chiefs. One end of a rope is attached to a pole fastened in the ground, the other to a sharp stick run through the skin of the chest of the candidate. His aim is to then circle about the pole until the stick is torn out. An observer writes that he has seen the skin pulled out to a distance of eight or ten inches before tearing. The elasticity of the connective tissue of the skin of a healthy person is evidenced by the ease with which the skin returns to its proper position after having been lifted and the hold relaxed. The "Elastic Skin Man," on exhibition a few years ago, had an abnormally elastic skin. The skin of the chin, for example, could be raised to the mouth, and when released promptly returned to its place.

PAGE **79**, § 76 (*a*). **The Production of Corns and Callous Spots.** — It is a law that *interrupted* pressure produces hypertrophy, *i.e.* an increase of nourishment or supply, resulting in an increase of size, and *constant* pressure produces atrophy, or a want of nourishment or supply, resulting in a decrease of size. "Callous" spots upon the knees of shoemakers and the chests of other workmen are to be ascribed to the interrupted pressure upon the respective parts, by lapstone and hammer, "brace and bit," "burnishers," "breast-drills," etc. Corns, in like manner, are the result of the irritation of certain portions of the epidermis lying near to the bones, by the interrupted pressure from shoes which are either too tight or too loose. On the other hand, the constant pressure of shoes, bandages, etc. (*i.e.* by night and by day), will cause atrophy, as may be seen in the deformities of the feet of certain Chinese girls.

PAGE **80**, § 78 (*a*). **The Vast Number of Pores and Drainage Tubes of the Skin.** — "Taken separately, the little perspiratory tube, with its appended gland, is calculated to awaken in the mind very little

"1. The normal breathing of woman is like that of man — abdominal. Waist constriction changes the type of breathing to costal.[1]

"2. The pelvic organs, normally, make a considerable excursion with each respiration. Waist constriction in the upright position checks this motion almost entirely.

"3. Sitting or bending forward lessens the pressure within the abdomen. Waist constriction in these positions greatly increases intra-abdominal pressure.

"4. The abdominal organs are displaced downward by waist constriction, and at times to an extreme degree.

"5. The pelvic floor is bulged downward.

"6. The circulation in the pelvis is obstructed.

"7. The abdominal wall suffers by thinning of muscle and accumulation of fat, and the trunk muscles waste.

"8. The chest expansion is crippled by compression of the lower ribs and the check on the play of the diaphragm.

"9. The capacity for outdoor exercise is hampered." — Dr. R. L. Dickinson, *Simple and Practical Methods in Dress Reform.*

Page **107**, § 108 (*a*). **Some of the Risks attending the Use of Unclean Clothing.** — "Unclean clothing is sometimes a direct means of conveyance of disease. The unclean fabric becomes saturated with poisonous substances, with the fumes of tobacco, for instance, and holds its wearer in a persistent atmosphere charged with unwholesome vapor. Still more seriously it becomes the medium of the poisons of the spreading diseases. I could cull from my note-books many examples of the last-named danger, but must be satisfied to mention one or two striking and brief illustrative facts. I have known scarlet fever carried by the clothing of a nurse into a healthy family, and communicate the disease to every member of the family. I have known cholera to be communicated

[1] "*Abdominal respiration is essential to woman's health; clothing must be worn that does not restrict it.* All women who wear corsets and tight waistbands breathe with a distinct movement of the upper chest. This costal or thoracic respiration is as unnatural to the woman as it is to the man. Mays has shown by tracings that Indian girls breathe like men, Kellogg has elaborately confirmed the observation among various Indian tribes, among Chinese women, agricultural women, and English pit-brow lassies, and Wilberforce Smith has added his evidence. All agree that civilized women who have been in the habit of wearing clothing truly loose about the waist show the same type. Women asleep breathe like men, and male and female animals breathe alike." — Dr. R. L. Dickinson.

by the clothes of the affected person to the women engaged in washing the clothes. I have known small-pox conveyed by clothes that had been made in a room where the tailor had by his side sufferers from the terrible malady. I have seen the new cloth, out of which was to come the riding-habit for some innocent child to rejoice in as she first wore it, undergo the preliminary duty of forming part of the bedclothing of another child stricken down with fever. Lastly, I have known scarlet fever, small-pox, typhus, and cholera communicated by clothing contaminated in the laundry." — Dr. B. W. Richardson, *Diseases of Modern Life.*

Page **122**, § 121 (*a*). **Relief of Constipation.** — Constipation, or a sluggish condition of the bowels, is very common, and has much to do with ill health. The following suggestions for relief will neither answer for all persons, nor always take the place of medicinal measures, which should come from the attending physician : 1st. Daily muscular exercise, especially walking, if not carried beyond the strength of the individual. Too much exercise may aggravate the trouble. 2d. A cold bath before breakfast for those who can stand it. 3d. Moist compresses (*i.e.* several thicknesses of cloth) applied for two or three hours daily over the abdomen. 4th. Daily kneading of the bowels, especially in the course of the large intestine. 5th. A glass of hot or cold water before breakfast, or water in which a few cloves have remained over night, or in which there is just enough salt to give a *slight* saline taste. 6th. Fruit ; oranges, apples, bananas, or grapes, before or at breakfast ; figs, dates, and other similar fruits throughout the day, in small quantity, or stewed fruit for supper, or a baked apple before retiring. 7th. Oatmeal, Indian meal, Graham bread, Graham crackers, sardines, coffee (for some persons, tea), molasses, molasses cake, zwieback, etc.

While the above measures, used with discrimination, are of value, it is but right to state that many persons, especially those who take but little exercise, are liable to carry the hygienic treatment to extremes, and to injure their digestive organs by much indigestible food.

Page **127**, § 124 (*a*). **The Importance of Thorough Chewing of Food.** — The value of insalivation in connection with mastication becomes apparent when we consider how difficult it is to chew dry substances like crackers until they are moistened. It is also almost impossible to swallow substances which are very dry. The value of a thorough *comminution of food*, in making it more soluble, is shown by a comparison of the length of time it takes for a lump of sugar to dissolve in water, with that consumed by a similar lump broken into fine particles, in the

same amount of water. Imperfect chewing and the absence of sound teeth produce many a dyspeptic. On the other hand, the filling of teeth, or the substitution of a good artificial set for teeth which are worn out or decayed, has often furnished the dyspeptic the only means of cure. It is well known to veterinary surgeons that horses sometimes lose their appetite and strength on account of broken or irregularly worn teeth, which prevent them from chewing their food.

Old people and young children are very apt to bolt their food. As they do not chew well, their food should be thoroughly minced for them.

PAGE **135**, § 134 (*a*). **Time occupied in the Digestion of Various Articles of Food.** — In 1822, Alexis St. Martin, eighteen years of age, a *voyageur* in the employ of the American Fur Company, was wounded in the left side, the ball perforating the stomach. Through an opening which did not heal entirely for a number of years, Dr. Beaumont of the United States Army was enabled to watch the digestion of foods in the stomach. The following extract from a table prepared by Dr. Beaumont shows the digestibility of various foods. The estimates may be considered as approximative only, being founded upon an isolated case; still, experiments have been made upon animals which tend to confirm those made upon St. Martin.

	Hours.	Min.		Hours.	Min.
Pigs' feet, soused (boiled)	1	00	Mutton (roasted)	3	15
Tripe, soused (boiled)	1	00	Eggs (hard boiled)	3	30
Soup, barley (boiled)	1	30	Eggs (fried)	3	30
Trout, salmon, fresh (fried)	1	30	Potatoes, Irish (boiled)	3	30
Venison steak (broiled)	1	35	Oysters (stewed)	3	30
Milk (boiled)	2	00	Beets (boiled)	3	45
Cabbage, with vinegar (raw)	2	00	Green corn and beans (boiled)	3	45
Eggs, fresh (raw)	2	00	Salmon (boiled)	4	00
Apples, sour, mellow (raw)	2	00	Soup, beef, vegetables, and bread (boiled)	4	00
Milk (raw)	2	15	Duck, barn-yard (roasted)	4	00
Turkey (roasted)	2	30	Heart, animal (fried)	4	00
Eggs, fresh (soft boiled)	3	00	Pork, salt (fried)	4	15
Beefsteak (broiled)	3	00	Veal (fried)	4	30
Mutton, fresh (boiled)	3	00	Cabbage (boiled)	4	30
Soup, chicken (boiled)	3	00	Duck, wild (roasted)	4	30
Bread, corn (baked)	3	15	Pork, fresh (roasted)	5	15
Oysters, fresh (roasted)	3	15			

PAGE **174**, § 177 (*a*). **Oddities of Diet.** — Certain tribes of Indians in South America eat at times a peculiar kind of clay. Beetles were

eaten by Roman epicures, and are said also to be eaten by Turkish women for the purpose of fattening themselves. Bees, moths, ants, mice, and many small animals form staple articles of diet in some parts of the world. Humboldt tells us that centipedes are eaten with avidity by some of the natives of South America. Birds' nests, rats, and snails are eaten in China. The Tartars ate horses, camels, and dogs, and drank mare's milk. The Egyptians thought wheat, beans, and barley poor food, and did not eat the head of any animal. In Africa certain tribes will not eat sugar or drink milk.

PAGE **181**, § 187 (*a*). **Food Value of Sugar.** — "Certain rowing clubs in Holland report very beneficial results from the use of large amounts of sugar in training. It seemed to counteract the bad effects of a meat diet, so that the dreaded symptoms of overtraining did not appear. The rowers who used sugar always won because of superior endurance. . . . Professor Pflüger says that, without doubt, the sugar in the blood is heavily drawn on during violent exercise; hence the longing for it in a form that can be rapidly assimilated. . . . Its use by mountain climbers is well known. The Swiss guide considers lump sugar and highly sweetened chocolate an indispensable part of his outfit. . . . In India it is said that workmen must have daily large amounts of food well seasoned with sugar. The employer must furnish it or lose his workmen. In all tropical lands the consumption of dates, figs, and other sweet fruits is very large. . . . In small quantities and in not too concentrated form, sugar will take the place, practically speaking, weight for weight, of starch as a food for muscular work, barring the difference in energy and in time required to digest them, sugar having here the advantage. In times of great exertion or exhausting labor, the rapidity with which it is assimilated gives it certain advantages over starch." — MARY HINMAN ABEL, *Sugar as Food*, United States Department of Agriculture.

PAGE **182**, § 189 (*a*). **Use of Fat in Hot Climates.** — "Consider how olive-oil is used in the warm parts of Europe, and how ghee is used in India, in order to satisfy yourself that oily matter may be taken with facility in hot countries as well as in cold. You hear nothing about indigestion; you find that a bad olive harvest or a scant supply of ghee is a great national calamity. A Hindoo servant of a friend, who kept up his Indian habits of eating in London, has often told me that nothing would make up for a deficiency of ghee or butter, and that this was the common experience of his countrymen at home or away from home. He looked upon a sip of ghee in very much the same light as that in which his fellow-

servants looked upon a draught of beer. 'Wine is good, but oil is better,' said a peasant to the courier who was with me in Andalusia; and after gulping down a large mouthful of olive-oil, and smacking his lips more than once, the expression of his countenance was an apt illustration of the meaning of the Scriptural text which speaks of oil as making 'the face to shine.' Indeed, it may be taken for granted that oil may be used in large quantities throughout the year in the hot olive-growing countries of the south of Europe, not only without making people bilious, but with unmistakable benefit." — DR. C. R. RADCLIFF, *London Practitioner*, "*A Few Words About Eatables.*"

PAGE **183**, § 191 (*a*). **Use of Fat in Cold Climates.** — The accounts given by travellers of the amount of food, and especially of fat, eaten by the inhabitants of the frigid zone are almost incredible. The Russian admiral, Saritcheff, tells of a man who ate, in his presence, at a single meal, twenty-eight pounds of boiled rice and butter.

"Sir John Franklin tried how much fat an Esquimaux boy could consume: fourteen pounds of tallow candles quickly disappeared; and Sir John closed the experiment with a piece of fat pork, as he began to feel apprehensive for his stores. Oil is a luxury greedily devoured by the Northern races, as was amusingly proven in a seaport town some years ago. The town was lighted by oil lamps, and the inhabitants remarked that they went out for several successive nights; at last it was discovered that some Russian sailors in the harbor climbed the lamp-posts and drank the oil." — MAPOTHER, *Lectures on Public Health.*

PAGE **184**, § 192 (*a*). **Fasting. Importance of Water.** — "Without something to eat or drink, man will not live beyond a few days, or at most a week. Access to water, however, makes a great difference. There is a well-known case of an Ayrshire miner who lived twenty-three days, buried in a coal mine, without swallowing anything but small quantities of chalybeate water sucked through a straw. He had the advantage of being shut up in a contaminated atmosphere, which, by diminishing nervous sensibility, lessened the cravings of hunger. Berard quotes the example of a convict who died of starvation after sixty-three days, but in this case water was taken. Cases of alleged fasting longer than this are certainly due to imposture. The insane appear to bear fasting better than those in their sober senses; and, in some morbid conditions of the body, nourishment may certainly be done without for a surprising length of time. Animals have an advantage over man, so far as living without food is concerned." — *Cassell's Magazine.*

Page **185**, § 194 (*a*). **Salt; its Importance.** — "Animals will travel long distances to obtain salt; men will barter gold for it; indeed, among the Gallas and on the coast of Sierra Leone, brothers will sell their sisters, husbands their wives, and parents their children, for salt. In the district of Accra, on the Gold Coast of Africa, a handful of salt is the most valuable thing upon earth after gold, and will purchase a slave or two. Mungo Park tells us that with the Mandingoes and Bambaras the use of salt is such a luxury that to say of a man, 'He flavors his food with salt,' is to imply that he is rich, and children will suck a piece of rock-salt as if it were sugar. No stronger mark of respect or affection can be shown in Muscovy, than the sending of salt from the tables of the rich to their poorer friends. In the Book of Leviticus it is expressly commanded as one of the ordinances of Moses, that every oblation of meat upon the altar shall be seasoned with salt, without lacking; and hence it is called the Salt of the Covenant of God. The Greeks and Romans also used salt in their sacrificial cakes; and it is still used in the services of the Latin church — the '*parva mica*,' or pinch of salt, being, in the ceremony of baptism, put into the child's mouth, while the priest says, 'Receive the salt of wisdom, and may it be a propitiation to thee for eternal life.' Everywhere, and almost always, indeed, it has been regarded as emblematical of wisdom, wit, and immortality. To taste a man's salt, was to be bound by the rites of hospitality; and no oath was more solemn than that which was sworn upon bread and salt. To sprinkle the meat with salt was to drive away the devil; and to this day nothing is more unlucky than to spill the salt." — Letheby, *On Food.*

Page **193**, § 202 (*a*). **United States Army Ration.** — "There is in the army of the United States a considerable difference between the ration of the soldier and the diet of the soldier. The critics of the army ration do not understand this. The ration is the allowance for subsistence of one person for one day. The diet is what is actually prepared in the kitchen for consumption by the soldier day by day. The ration is prescribed by law, and consists of the meat, the bread, the vegetables, the fruit, the coffee and sugar, the seasoning and the soap and candle components. . . . The slightest knowledge of practical cookery will enable any one . . . to form an idea of what may be called the flexibility of the army ration. . . . If the proximate principles be calculated it will be found that many variations may be made in the relative proportions of proteids, hydrocarbons, and carbo-hydrates. . . . The ration is so elastic that the soldier may verily eat his candles if he does not require them for other purposes. He may leave the candles in the hands of the subsistence

department, and if their money value will pay for a can of peaches, or a pound of rice, or so much of any other of a long list of articles kept for sale by the subsistence officers, he can eat his candle component in the form of peaches and rice, or any other of the purchasable things. . . . So, indeed, with all the other components of the ration, excepting only the fresh vegetables, fresh bread, baking powder, and dried fruit. . . . There is even a greater elasticity than this to the ration, for the money credit for components not drawn and used may be applied to the purchase of articles from outside sources, articles not kept for sale by the subsistence department. . . . A soldier's ration is fixed by law, and it is a most liberal one, but his dietary depends upon the intelligent supervision of company officers and the ability of the company cooks." — Dr. Charles Smart, Deputy Surgeon General, U. S. Army.

The Ration.

Meat Components.

Fresh beef or fresh mutton (when the cost does not exceed that of Beef)	20 oz.
or Pork or Bacon	12 oz.
or Salt Beef	22 oz.
or Dried Fish	14 oz.
or Pickled Fish or Fresh Fish	18 oz.
or Canned Salmon	16 oz.

Vegetable Components.

Beans or Peas	$2\frac{2}{5}$ oz.
or Rice or Hominy	$1\frac{3}{5}$ oz.
Potatoes	16 oz.
or Potatoes ($12\frac{4}{5}$ oz.) and Onions ($3\frac{1}{5}$ oz.)	
or Potatoes ($11\frac{1}{5}$ oz.) and canned Tomatoes ($4\frac{4}{5}$ oz.)	
or $4\frac{4}{5}$ oz. of other fresh vegetables (not canned) when they can be obtained.	

Fruit Components.

Dried Fruits — Apples, Peaches, Prunes, etc.	2 oz.

Bread Components.

Flour or Soft Bread	18 oz.
or Hard Bread	16 oz.
or Corn Meal	20 oz.
Baking Powder, when necessary for soldiers to bake their own bread	$\frac{16}{25}$ oz.

Coffee and Sugar Components.

Coffee, green	$1\frac{3}{5}$ oz.
or Roasted Coffee	$1\frac{7}{25}$ oz.
or Tea, green or black	$\frac{8}{25}$ oz.
Sugar	$2\frac{2}{5}$ oz.
or Molasses or Cane Syrup	$\frac{16}{25}$ gills.

Seasoning Components.

Vinegar	$\frac{8}{25}$ gills.
Salt	$\frac{16}{25}$ oz.
Pepper, black	$\frac{1}{25}$ oz.

Soap and Candle Components.

Soap	$\frac{16}{25}$ oz.
Candles, when illuminating oil is not furnished	$\frac{6}{25}$ oz.

— U. S. Subsistence Department.

The "Travel Ration" for soldiers on forced marches consists of bread, beef, beans, coffee, and sugar.

PAGE **193**, § 202 (*b*). **Food.**

ESTIMATED DAILY NEEDS.

	PROTEIN. Grams.	FAT. Grams.	CARBO-HYDRATES. Grams.	CALORIES.
Children, 1 to 6 years	28 to 70	35 to 48	60 to 250	765 to 1400
Children, 6 to 15 years	75	37 to 50	250 to 400	2040
Women (Germany), moderate work	92	44	400	2425
Man (Germany), moderate work	118	56	500	3050
Man (United States), moderate work	127	113	494	3500
Active laborer (England)	156	71	568	3630
Writer, hard work	150	150	500	4060
Subsistence diet	57	—	—	1760

FOOD ACTUALLY CONSUMED.

U. S. Army ration		120	161	454	3851
U. S. Navy ration		143	184	520	4998
U. S. college students (boarding club)		138	184	622	4827
U. S. college foot-ball team		181	292	557	5742
U. S. well-to-do family		128	177	466	4082
U. S. teamsters (*hard* work)		254	363	826	7804
Italy, underfed laborers		82	40	363	2192
Average of ten farmers' families in Vermont, Connecticut, and New York	food purchased	101	136	483	3655
	food used	97	130	467	3515
Average of fourteen mechanics' families in Connecticut, New York, Tennessee, and Indiana	food purchased	110	161	425	3690
	food used	103	150	402	3465
Average of fourteen professional men's families in Connecticut, Pennsylvania, Indiana, and Illinois	food purchased	108	132	429	3438
	food used	104	125	423	3325
Average of twelve laborers' families in New York City	food purchased	103	119	356	2950
	food used	101	116	344	2905
Average of eleven poor families in New York City	food purchased	93	98	414	3005
	food used	93	95	407	2915

— PROFESSOR ATWATER.

PAGE **195**, § 205 (*a*). **Fresh Meat as a Preventive of Scurvy.** — Dr. T. J. Turner, Medical Director, United States Navy, in an article in the *Sanitarian*, April, 1884, shows that an ample supply of fresh meat, *i.e.* from animals killed on the spot, such as the walrus and narwhal, is superior to any form of preserved meat in the prevention of scurvy, in that it furnishes the necessary salts and acid (probably lactic acid). In

fact, he speaks of fresh raw animal food as the best anti-scorbutic. Where it cannot be obtained in sufficient quantity, he suggests that a mixture of sodium, potassium, and calcium phosphates be added to preserved and cooked meats or other foods, and that lactic acid be added to the vinegar used as a condiment.

The experience of armies shows that fresh meat is more wholesome than canned meat. It is now carried by many vessels in refrigerators.

PAGE **198**, § 207 (*a*). **Economy in Food.**

THE CHEAPEST FOOD. — "The cheapest food is that which furnishes the most nutriment at the least cost. The most economical food is that which is both healthful and cheapest. . . . When the mother goes to market to make her purchases, she is thinking of meat, and flour, and potatoes, what they cost, and how the folks at home will relish them. . . . Her real problem, though she does not understand it, is to get the most and the best nutriment for her money. . . . She is to obtain, at the least cost, protein, fats, and carbo-hydrates needed to meet the wants of her family. Flavor and appearance are things to look out for, of course. She may buy them in the food if she has the money and is willing to spend it, but they are costly. She may supply them by good cooking and tasteful serving, but this will take skill and care, and too many women in her circumstances lack the one and are averse to the other. Or she may ignore both flavor and appearance, and if her husband does not like the food she sets before him, and other things about the home are not attractive, he will very likely go to the 'poor man's club,' otherwise known as the saloon. . . . If she spends a dime for beefsteak at 20 cents a pound, she gets half a pound, which supplies 0.08 pound of protein and 550 calories of energy; but if she invests the same money in flour at 2½ cents per pound she has 4 pounds, with 0.44 pound of protein and 5.680 calories of energy." — PROF. W. O. ATWATER, *Food and Diet.*

ECONOMICAL AND NUTRITIOUS FOOD. — "There is an unfortunate prejudice among us against learning of foreign countries. The American workman says indignantly that he does not want to learn how to live on 'starvation wages.' But the facts, viewed coolly, are just these: The inhabitants of older countries have learned some lessons that we too must soon learn, whether we will or no, and to profit by these lessons before we are really obliged to will in no way lower wages; it will simply help us to get more comfort and pleasure out of our money. Students of economy, political and domestic, find no better school than the experience of older countries, and consequently draw lessons from their greater thrift and economy in living. Mrs. Helen Campbell found, among the poor

sewing women of New York, that none were skilful in cooking their scanty food, excepting only the German and Swiss women. All observing travellers unanimously give this testimony: 'If our American workman knew how to make as much of his large wage as the foreigner does of his small one, he could live in luxury.' But, you ask, what are the special lessons to be learned of the foreign housewife? We answer, chiefly self-denial and saving. Do not give up in despair because you have a small income, and resign yourself to living meanly, in a hand-to-mouth fashion. Diligent study of the question and resolute abstention from luxuries will solve the problem, if it can be solved. We indulge ourselves and our children too much in what tastes good, while all the time we have not money enough to buy necessaries. . . . We seem, in general, to spend too much money in our country on food compared with what we use in other directions; our great trouble is that we do not know how to save every scrap of food and use it again in some form. For one thing, we have yet to learn the great art of soup making, — and, it seems, also of soup eating. The American housekeeper would say to me: 'This is nothing new; for years we've been hearing about soups. We don't like soups.' I only ask, 'Have you tried them for a considerable length of time, so that you have become skilled in making them, and your family used to their taste?' One fact alone ought to insure for them a good trial: that at least three nations, the German, French, and Italian, make daily use of them, and have for generations. To take part of our food in this form is an absolute necessity, if we are to do the best possible with a certain amount of money." — Mrs. Mary Hinman Abel, *Practical Sanitary and Economic Cooking.*

Page **200**, § 209 (*a*). **The Importance of Good Cooking.**

How Good Cooking pays. — "Foul air and overcrowding would, however, be less fatal in its results were food understood. The well-filled stomach gives strange powers of resistance to the body. . . . Happily, to know an evil is to have taken the first step in its eradication. . . . To have made cooking and industrial training the fashion is to have cleared away the thorny underbrush on that debatable ground, the best education of the poor. . . . That cooking schools and the knowledge of cheap and savory preparation of food must soon have their effect on the percentage of drunkards no one can question. Philanthropists may urge what reforms they will — less crowding, purer air, better sanitary regulations — but this question of food underlies all. The knowledge that is broad enough to insure good food is broad enough to mean better living in all ways. . . . One woman, who has learned in any degree to order her own

home and life aright, will be more a power with those among whom that life passes than a dozen average preachers." — MRS. JAMES T. FIELD, *How to Help the Poor.*

THE HIGH CALLING OF A COOK. — "Bad cooking is the rule, good cooking the exception. The truly artistic cook — the veritable *cordon bleu* — is a rare bird with us. The calling of a man cook ranks a little above that of the waiter-man; it is, perhaps, nearly up to that of a first-rate barber or hair-dresser. Almost invariably the professional male cook is an exotic production, — generally imported from France, — the calling being beneath the dignity of a native American not of African descent. A hired woman cook holds her head somewhat higher than the waitress and laundress, not so much on account of her superior rank, as from certain advantages of her position. The responsibility of cooking, however, in small households either rests with a maid of all work, or it is assumed by the mistress, whose qualifications are derived from perhaps a little experience, the possession of some family receipts, and, possibly, a cook-book. I shall not linger on this topic, but leave it with a few assertions. If alimentation have the importance and dignity which I have claimed for it; if appetite and taste are to be estimated by their physiological relations, the functions of a cook are of a higher grade than that denoted by the facts just stated. A skilful cook, male or female, is entitled to as much distinction, at least, as a clever mechanic. The calling should be reckoned an honorable one. The science and the art of cooking should be taught by competent professors, and should be embraced in the curriculum of female schools. More than this, here is a field for discoveries, inventions, and continued progress. To devise new combinations and culinary processes is a worthy object of study and experiment. He who may originate a new article of diet, palatable, digestible, and nutritious, by utilizing materials which are readily available, deserves something of the credit belonging to one who makes two blades of grass grow where but one grew before." — DR. AUSTIN FLINT, *Food in Its Relations to Personal and Public Health*, a paper read at the annual meeting of the American Public Health Association, 1876.

PAGE **201**, § 210 (*a*). **The Preservation of Food.**

METHODS OF PRESERVING FOOD FOR TRANSPORTATION. — The value of proper canning and of other methods of preserving food are well illustrated in the detailed instructions as to provisions, given by the Navy Department to the commander of the Greely Relief Expedition in the spring of the year 1884. Macaroni and vermicelli, bacon, preserved cranberries, etc., are to be packed in air-tight wooden kegs; marrow beans, dried

green peas, dried Lima beans, sweet corn, pork, salt beef, etc., in well-seasoned, tight half-barrels; baking-powder, compressed vegetables, mince-meat, evaporated fruit, fried potatoes, roast chicken and turkey, head cheese, sausages, apple and peach butter, candied lemon-peel, figs, tamarinds, cooked corn, beef, preserved beef and mutton, raw and fried oysters, sardines, butter, etc., in hermetically sealed tins; smoked and dried meats, well covered with canvas. Fried oysters and eggs (boiled twenty minutes) are to be put into cans and covered with hot lard. "The special mackerel and special salmon shall be of the best quality, and warranted to keep two years."

Improper Canning of Food. — "The intelligent purchaser will not buy a can of goods in which the brown streak of resin is not visible at the soldering point. To deceive him, it is alleged, the canners have adopted the habit of 'bronzing' the tops of cans to conceal the absence of the resin stain. It is fair to infer that bronzed cans are soldered with muriate of zinc amalgam. . . . Every cap should be examined, and, if two holes are found in it, send it at once to the Health Board, with the contents and the name of the grocer who sold it. Reject every article of canned food that does not show the line of resin around the edge of the solder on the cap, the same as is seen on the seam at the side of the can. 'Standard,' or first-class goods, have not only the name of the factory, but also that of the wholesale house which sells them, on the label. 'Seconds,' or doubtful or 'reprocessed' goods, have a 'stock label' of some mythical canning house, but do not have the name of any wholesale grocer on them. Reject all goods that do not have the name of the factory, and also the name of some wholesale firm, on the label. A 'swell,' or decomposing can of goods, can always be detected by pressing in the bottom of the can. A sound can pressed will give a solid feel. When gas from the decomposition of the food is inside the can, the tin will rattle by pressing up the bottom as you displace the gas in the can. Reject every can that shows any rust around the cap on the inside of the head of the can. If housewives are educated to these points, then muriate of zinc amalgam will become a thing of the past, and dealers in 'swells' have to seek some other occupation." — Dr. J. G. Johnson, *Medico-Legal Society,* Feb. 9, 1884.

Page **207**, § 214, Note 1 (*a*). **How to utilize Remnants of Food.** — "Nothing so well symbolizes the economical habits of continental Europe, and especially France, as the *pot au feu.* This is an iron pot kept constantly simmering upon the fire, into which is put from day to day all the wholesome remnants of food, which in this country are thrown away. Our people, in their magnificent way of doing things, never stop to con-

sider how much nutriment adheres even to well-picked bones of porter-house steak, mutton chops, ribs of beef, legs of mutton, etc. All these, and many things besides, are put into the *pot au feu ;* water, seasoning, and fragrant herbs are added as required, and the constant simmering — a solvent for even the toughest of Texan beef — extracts every particle of marrow, even, and the bones come out as clean and white as if they had been bleached in the sun. Among the common people, more than half of the nutriment of the day comes from the *pot au feu,* and if any member of the family comes home at an unusual hour hungry, it affords at all times a meal at once warm and wholesome. This explains how, as Hugh McCulloch tells us, the forty millions of France could live on what the forty millions of America throw away; and when we consider the wretched cookery that prevails in this country, it is not too much to affirm that they live twice as well as do our farmers and day laborers." — *Lancaster Farmer.*

PAGE **208**, § 214 (*a*). **The too Frequent Use of Meat.** — Undoubtedly, meat is too frequently used to the exclusion of other foods. For children, meat once a day is sufficient. The report of Dr. D. M. Camman, physician to the Orphans' Home and Asylum of the Protestant Episcopal Church, New York City, in the *N. Y. Medical Journal,* March 29, 1884, shows that for the last *twenty-five years* the children in that institution under eight years of age have received *no meat,* but in place of it an abundance of milk; yet the health of the children has been unusually good. The eating of meat three times a day, except by persons who do *very hard physical* work, taxes the eliminating organs. The effects of too much meat combined with too little exercise are frequently manifested in the biliousness, headache, gout, etc., which befall persons who "live high." Few people need meat, ordinarily, more than twice a day; in summer, not more than once a day. The sick are often inclined to consider meat, or meat teas, soups, and broths, as the most nutritious foods they can take, and hence sometimes delay their recovery by overtaxing the liver and kidneys.

PAGE **208**, § 214 (*b*). **The Adaptation of Food to the Digestive Powers.** — "Nature has provided for the young of the mammalia, in milk, food containing all the elements of nutrition in a semi-prepared state, which only requires a very short time for its thorough transformation into chyle. The same may be said of all oviparous animals, for they live on the contents of the egg in the early stage of their existence. Nature has evidently wished to spare the delicate organs of the young, in the earliest

period of life, the labor which they are destined later in life to undergo, in the elaboration of their food.

"The stomach of the strong man, of the navvy, of the drayman, may be compared to a quartz-crushing machine. It wants quartz—that is, strong, coarse foods, bread, bacon, pork, beef, to work upon—to crush. To give it eggs and milk would be like putting trifle or blanc-mange into the quartz-crushing machine; it would merely put it out of gear. On the other hand, the child, the delicate woman, the dyspeptic, the invalid, have stomachs that may be compared to a light chocolate-crushing machine. Quartz they cannot crush, and the attempt would ruin the machine, although it may be perfectly equal to crushing light things, such as chocolate, eggs, etc. In sickness and in deranged health the digestive organs lose their tone and powers, and should be treated as Nature treats the young; that is, the kind of nitrogenous food should be given which entails the least work on the part of the stomach. It is weakened, its muscular and secreting powers are diminished, and it no longer requires for its health many hours of rude exercise daily."—*Nutrition in Health and Disease.*

PAGE **208**, § 215 (*a*). **The Relative Value of Various Meats.**—An inquiry among various charitable institutions shows that beef is relished best, and in the form of stews; next, mutton and pork; then fish, especially in the form of chowder. Of late years, a great deal has been said against the use of pork, and undoubtedly much of the pork sold to and used by the poor is unfit to eat. But if pigs are fed largely upon corn, and are kept well cleaned and housed, they yield healthy pork. The flesh of all animals is affected by transportation in badly ventilated cars, and even the method of killing influences the quality of the meat.

PAGE **210**, § 216 (*a*). **Raw Oysters.**—"'Our practice in regard to the oyster is exceptional, and furnishes a striking example of the general correctness of the popular judgment on dietetic questions. The oyster is almost the only animal substance which we eat habitually and by preference in the raw or uncooked state; and it is interesting to know that there is a sound physiological reason at the bottom of this preference. The fawn-colored mass which constitutes the dainty of the oyster is its liver, and this is little less than a mass of glycogen; associated with the glycogen, but withheld from actual contact with it during life, is its appropriate digestive ferment,—the hepatic diastase. The mere crushing of the dainty between the teeth brings these two bodies together, and the glycogen is at once digested, without other help, by its own diastase. The oyster, in the

uncooked state, or merely warmed, is, in fact, self-digestive. But the advantage of this provision is wholly lost by cooking, for the heat employed immediately destroys the associated ferment, and a cooked oyster has to be digested, like any other food, by the eater's own digestive power.' This graphic description by Dr. Roberts tells us how it is that oysters *au naturel* are so much in vogue for invalids, as they deservedly are. Also, why oysters should not be cooked in oyster sauce, but put into the prepared sauce just as it comes to table; why, as King Chambers insists, in a beefsteak pudding, the oysters should not be cooked, but a flap of the paste raised, and the oysters popped in, just as the pudding is served. In making oyster pâtés, the paste is cooked in bread-crumbs, which is then taken out and the oysters put in; after which, the pâtés are just warmed, and no more, and then brought up to the dinner table. The idea that long cooking increases the digestibility of food is not always correct." — FOTHERGILL, *Indigestion and Biliousness.*

PAGE **210**, § 217 (*a*). **Decomposing Food to be guarded against.** — "Under ordinary circumstances, many cases are recorded in works upon poisons, such as Dr. Christison's, where decayed animal food has produced severe and even fatal diarrhœa, in spite of cookery having concealed some of its repulsiveness. High game has fortunately gone out of fashion, and the most frequent form in which we now meet with decomposing albuminoid matter is that of a fusty egg. Some housekeepers seem to consider this quite good enough for made dishes, and thus spoil material worth ten times what they save by their nasty economy. No egg should be allowed to enter the kitchen that has the slightest smell of rotten straw." — DR. T. K. CHAMBERS, *Manual of Diet.*

PAGE **210**, § 217 (*b*). **Selection of Meats.** — "Good meat has the following characters: 1. It is neither of a pale pink color nor of a deep purple pink, for the former is a sign of disease, and the latter indicates that the animal has not been slaughtered, but has died with the blood in it, or has suffered from acute fever. 2. It has a marbled appearance from the ramifications of little veins of fat among the muscles. 3. It should be firm and elastic to the touch, and should scarcely moisten the fingers — bad meat being wet and sodden and flabby, with the fat looking like jelly or wet parchment. 4. It should have little or no odor, and the odor should not be disagreeable, for diseased meat has a sickly, cadaverous smell, and sometimes a smell of physic. This is very discoverable when the meat is chopped up and drenched with warm water. 5. It should not shrink much in cooking. 6. It should not run to water or become very

wet on standing for a day or so, but should, on the contrary, dry upon the surface." — LETHEBY, *On Food.*

PAGE **212**, § 218 (*a*). **Milk.** DIFFICULTIES IN OBTAINING PURE MILK. — "The first thing to be borne in mind is that milk is naturally a pure product. If any milk is found unclean, unwholesome, or disproportioned in its proper parts, the chances are that it is not the fault of the cow. In all such cases the presumption is that some person is to blame, either the one who cares for the cow or the one who handles the milk. . . . There is a great desire to get milk cheap, and it is not an unknown thing for customers, including hotels and private institutions, as well as private families, to demand such large measure for their money that the dealers feel compelled to 'extend' the milk in order to meet these requirements and prevent loss of trade. Some are satisfied with the adulterated stuff, not knowing that the same amount of actual food, but no more and perhaps less, is being delivered in the large measure than was formerly delivered in the small one. This explains how it sometimes happens that milk is retailed in cities at less than the regular wholesale price. People too easily forget quality and think only of quantity. The only sensible thing for the housekeeper or other buyer of milk to do, is to willingly pay a fair price, and insist upon good milk in return. Buyers should remember that, at the highest prices usual anywhere, good milk is about as cheap an article of food as can be purchased. It should also be borne in mind that milk can be contaminated as easily after delivery to the family or consumer as before, and too often a milkman is blamed for bad milk or cream when it was made so by conditions over which he had no control. If left where dust can settle in it or flies have access to it, or if set in an ill-ventilated cellar or in a warm place, it is pretty certain to be in bad condition after a few hours, no matter how good it was when delivered. Numerous well-authenticated cases are known where customers have complained of milk received, and upon investigation it has been proved that servants in the house tampered with the milk, removing cream for their own use or adding old milk or vinegar to make it sour prematurely. The object of the latter act was, in connivance with an outsider who supplied the motive, to cause the buyer to change to some other dealer whom the servant was ready to recommend." — R. A. PEARSON, *Facts about Milk*, U. S. Department of Agriculture.

CHANGES OF MILK. — "Thunderstorms, impurities, warm temperature, and other conditions known to exist when milk is most liable to give trouble have been blamed for its changes. But it is now known that these are only indirect causes, and that the changes in milk which bother the

housekeeper are due to, and cannot take place without, the presence of minute organisms called bacteria. . . . Any milk having a large amount of sediment is suspicious. Particles of dirt are a sign that germs are abundant. Thus dirty milk may be dangerous as well as disgusting. The dirt in milk consists mostly of particles of dead skin and manure, which fall into the pail from the body of the cow during milking; but dust in the stable, and dirt and dust in the vessels used for handling milk, and unclean attendants, are also common sources of dirty sediment in milk. Milk from unhealthy or unthrifty cows, or that which has been handled by sick persons is dangerous, as it may contain infectious germs or foreign substances which might affect the health of the consumer. The germs of typhoid fever, scarlet fever, diphtheria, and consumption (or tuberculosis) have been found in milk, and thus transmitted to man, and spread from family to family. Feverish cows, . . . and sometimes cows that have been milked a long time, produce milk which should not be used. Any milk having an unnatural appearance should be discarded. Odors and peculiar flavors are due to bacterial action or to the volatile oils of some foods; onions, turnips, cabbage, and certain weeds, as garlic and wormwood, give characteristic odors and tastes to milk." — *Ibid.*

Care of Milk. — "The proper care of milk after it has been delivered to the consumer is a matter of great importance. . . . If milk is kept in an open vessel in a refrigerator with meats and various kinds of vegetables, it will absorb odors from them. It is also sensitive to flavors, and if allowed to stand in an old tin dish the 'tin taste' can easily be recognized. Milk should therefore be kept in a cool place, free from odors, and in a perfectly clean vessel of suitable material. A well-glazed earthen or porcelain dish, or a glass jar or bottle, is the best container; tin is good so long as bright and the iron is well-covered. Wooden dishes are objectionable.

"As already stated, the change to which milk is most liable is simple souring, and the best agents to prevent this change are cold and heat. Too much care cannot be used in seeing that the milk is cold when delivered, and that it is then immediately put into a cool place. If allowed to stand in the warm air, even for a few minutes, the time it will keep sweet is shortened. Of course it will keep longer at a temperature between 35° and 50° F. than above 50° F. Sometimes milk does not keep sweet when no cause can be discovered for its souring. This is frequently the case in summer. Often the trouble is the refrigerator, which may seem cold on account of the great difference between its temperature and that outside, while it is, in fact, not cold, and a thermometer may show its temperature to be even above 60° F." — *Ibid.*

Page **216**, § 224 (*a*). **The Importance of Vegetable Food.** — "The commonest fault committed by housekeepers in respect of vegetables is, that they do not supply a sufficient variety, seeming to consider that the meat is the only part of the meal that requires care, and that all the rest is mere garnish, beneath the notice of a Briton, and unfit to sustain his vigorous life. Yet that is not the experience of the observers of mankind. The attention of Herodotus was called to the fact that the Persians, the manliest and most sporting nation in the world, had at meals not only several dishes, but several courses of vegetable food, preceding a very moderate allowance of solid meat. And Sir Henry Rawlinson describes the diet of this tough race as practically the same now; so that the assumptions of some anthropologists that hunting races are necessarily riotous eaters of flesh, and that carnivoracity strengthens a nation, are not accurate. The Persian gentleman is the spiritual father of the British squire; yet, at many a hospitable board, if a guest does not fancy meat that day, or has eaten enough of it at a previous meal, he will have to fall back upon potatoes, or to solace himself by picking a few bits out of the sauces of made dishes, where the vegetable flavor has been saturated with that of meat, and spoilt. Usually, he goes on eating too much nitrogenous food out of sheer idleness." — Chambers, *Manual of Diet.*

Page **216**, § 224 (*b*). "'**Potatoes as Food for Man**' is the subject of a farmers' bulletin issued by the United States Department of Agriculture. This shows that the potato, being essentially a starchy food, to be wholesome should be eaten with meat, eggs or fish, which are essentially nitrogenous foods. Eaten alone the potato furnishes a one-sided, badly-balanced diet. The report shows that the reason why potatoes have been a staple article of diet for years is in accordance with the scientific principle that one food must supply the deficiency of another. The most important groups of constituents in foods are protein (nitrogenous matter), fats, and carbohydrates (starches, sugars, etc.). Hence, when potatoes are eaten with foods largely nitrogenous, they supply a well-balanced diet, conducive to health and vigor. There is a tendency to decry the potato, and it certainly need not be served three times a day, as it is in many households, simply because the housewife has not the culinary knowledge to find substitutes. There are many pleasing ways of preparing them all winter, but these are the days when they are least desirable, and when the careful housewife will replace them as often as possible with substitutes. In the spring, when old potatoes are at their worst and new ones little better, they should be entirely replaced

by such articles of food as hominy, served hot with a bit of crisp bacon for breakfast; with rice, boiled, fried, or in croquettes; with macaroni, spaghetti, or even beans. Such substitutes will be found more palatable and far more healthy, even in households which have deemed nothing could take the place of the everlasting potato, served three times a day and seven times a week."

PAGE **217**, § 224 (*c*). **Salads.** — "Vegetables intended to be used for salad should all be fresh and crisp, and sweet and clean. Their colors should be positive and even; the reds very red, the whites very white, and the greens pure as those in an autumn sunset sky, except in the full-grown leaves, such as watercress. . . . With a little trouble, not, however, necessarily attended by expense, a succession may be provided of materials for salad all the year round, so as to have one at table every day. And a great preservation of health I believe it to be for hearty persons. The most difficult season to provide for is the latter end of winter, and it may be of use to mention that the *dandelion* is then a friend in need. If a pot be placed over the plant as it grows, or the leaves tied up like lettuce, or it be transplanted into a frame, it can be bleached, and thus loses its bitterness. Daisy leaves are also eatable; and thus, with a sprig of tarragon, a few cold potatoes, and some ever-constant mustard and cress, giant cress, Australian or curled cress, an olive or two pared thin, or some beet root and a slice of Madeira onion, a great variety of combinations may be made." — CHAMBERS, *Manual of Diet.*

PAGE **217**, § 224 (*d*). **The Food Value of Peas, Beans, etc.** — "Then there are the vegetable albuminoids, especially the pulse tribe, or legumes, which are capitally disintegrated by cooking, and best by boiling or baking. Thus beans, haricots and broad, peas, lentils, dahl, etc., are all well broken up by heat. The disintegrated flour can easily be passed through a sieve, and then the disintegration factor of the digestive act is disposed of. There can be no question about the fact that with some persons vegetable albuminoids are much more easily digested than animal albuminoids; and I quite agree with Sir Henry Thompson in his remarks upon this subject. Besides, too, fat spreads easily over the disintegrated particles of cooked vegetable albuminoids, as is well seen in the baked beans and fat pork of New England. Indeed, by such means fat can often be taken without offence to a stomach that cannot otherwise tolerate it; and much of the digestibility of fat depends upon the fineness of the particles into which it is subdivided. Haricot beans well

boiled, passed through a sieve, and then the floury part mixed with milk, make an excellent soup; quite equal in food value to any made with meat stock. The ordinary lentil soup is at once a most economical and a most valuable soup, though scarcely, perhaps, quite adapted for persons with indigestion. But 'the proof of the pudding is in the eating thereof,' —if it does not disagree, there is certainly no objection to its use." — FOTHERGILL.

PAGE **218**, § 225 (*a*). **The Quenching of Thirst by Fruit rather than by Liquor.** — "Some dyspeptics find that they must take no fluids with their food, and have to live on a very dry dietary, an Arab dietary. Others require more fluids than they allow themselves. Others require a biscuit, or some light article of food 'betwixt meals.' When this is made an excuse for a glass of sherry, it is to be closely criticised as a questionable habit, 'more honored in the breach than the observance.' To take some fruit would be better in every way. Some succulent fruit would satisfy the craving 'for something,' and would not require the beverage 'to get it down.' Such use of fruit ought to be more general than it is at present. In all households where the expense does not forbid it, a large dish of picked fruit of various kinds, when the season permits of it, should be placed on the sideboard every morning, with a label 'Help yourself' on it (as is found in the waiting rooms of several London consultants). Children would soon cease to overeat themselves, just as do the assistants in confectioners' shops, when they realize that it is to be a constant affair, not an occasional treat to be made the most of. Such an idea is well worthy of adoption. If the 'temperance' section of society would set the example, it would soon be followed by others, to the benefit of the digestive organs of many while it would be agreeable to all. Fresh gathered fruit out of the garden and orchard ought to be placed on the breakfast table every morning. For those who experience a bitter or hot taste in the morning on awakening, such addition to the breakfast table would be most acceptable." — FOTHERGILL, *Indigestion and Biliousness.*

PAGE **219**, § 226 (*a*). **The Use of Savory Herbs.** — Miss Corson, superintendent of the New York Cooking School, in her *Cooking Manual*, says: "Sweet and savory herbs are absolutely indispensable to good cooking; they give variety and savory flavors to any dish into which they enter, and are nearly all of some decided sanitary use; the different kinds called for in the various receipts further on in this work can be bought at almost any grocery store, or in the market; but we advise our readers to obtain seeds from some good florist and

make little kitchen gardens of their own, even if the space planted be only a box of mould in the kitchen window. Sage, thyme, summer savory, sweet marjoram, tarragon, sweet basil, rosemary, mint, burnet, chervil, dill, and parsley will grow abundantly with very little care; and when dried and added judiciously to food, greatly improve its flavor. Parsley, tarragon, and fennel should be dried in May, June, and July, just before flowering; mint in June and July; thyme, marjoram, and savory in July and August; basil and sage in August and September; all herbs should be gathered in the sunshine, and dried by artificial heat; their flavor is best preserved by keeping them in air-tight tin cans."

PAGE **219**, § 227 (*a*). **Ice and Ice Water.**— "About three pints of fluids are the normal allowance of water to human beings in a temperate clime under ordinary circumstances; but when there is much perspiration, induced by exertion or other cause, a much larger quantity is necessary. In iron works, the men, exposed to high temperature and bathed in perspiration, when at work drink from two to four gallons of fluids per diem. There is a popular prejudice against drinking freely of cold fluids when heated, and no doubt death is sometimes so induced; but the consumption of cold and even chilled drinks is now much on the increase. Ice is no longer regarded as a mere luxury; it has become a necessary of life in hot weather, and its addition to a beverage adds much to its agreeableness. The chilled fluid directly lowers the heat of the body, and abstracts from it as much heat as is requisite to raise the temperature of the chilled fluid to that of the body, that is, from about 32° to 99°; this exercises a distinct influence over the body temperature for some time. It is obvious from this that the quantity of the chilled fluid has much to do with the effect, and a pint will take twice as much heat to raise its temperature as will half a pint. Consequently it is not unimportant to the imbiber what the amount of his fluid is, as well as its temperature; and to those who produce heat but slowly a sip of iced fluid is as cooling as a draught of it to another whose heat-forming power is great. The draught of the latter would be as dangerous to the first as the sip of the first would be useless and ineffective to the latter. At all entertainments, dancing and other, where the heat becomes great, ice, both as a beverage and in the more solid form of ice cream, forms now the essential matter of the refreshment table, and is very acceptable. It must be remembered, however, that free indulgence in iced fluids is very apt to induce a sharp diarrhœa in many persons. Also the free consumption of ice has not unfrequently the effect of creating even a stronger craving than ever for fluids, from the same action upon the throat that

snowballs have on boys' hands, — the persistent cold causes a free flow of arterial blood to the part. In such cases a drink of warm fluid often gives relief."— FOTHERGILL, *Maintenance of Health.*

PAGE **220**, § 228 (*a*). **When Scum and Water Weeds are Harmful.** — According to Prof. W. G. Farlow, M.D.,[1] "The flowering plants known as water weeds, both those that grow from the bottom of ponds and watercourses, and have distinct stems and leaves, and also those that float on the surface as scum, are, under ordinary circumstances, harmless. They may prove (1) troublesome or injurious by growing so luxuriantly as to choke up small streams and shallow ponds; (2) by serving as points of attachment or shelter for injurious small plants; and (3) by decaying in hot weather."

PAGE **220**, § 228 (*b*). **A Simple Test for the Purity of Water.** — "Fill a bottle made of colorless glass with the water; look through the water at some black object; the water should then appear perfectly colorless and free from suspended matter. A muddy or turbid appearance would indicate the presence of soluble organic matter, or of soluble matter in suspension. It should be 'clear as crystal.'

"Empty out some of the water, leaving the bottle half full; cork up the bottle and place it for a few hours in a warm place; shake up the water, remove the cork, and critically smell the air contained in the bottle. If it has any smell, and especially if the odor is in the least repulsive, the water should be rejected for domestic use. By heating the water to boiling, an odor is sometimes evolved that otherwise would not appear.

"Pure water should be tasteless and remain so after being warmed. It should also be odorless; but, since the delicacy of smell and taste varies greatly, sanitarians attach special importance to Heisch's test for sewage contamination or the presence of putrescible organic matter. A clean pint bottle is filled three fourths full of the water to be tested, and in the water is dissolved a teaspoonful of the purest sugar — loaf or granulated sugar will answer; the bottle is then corked and kept in a warm place for two days. If in from twenty-four to forty-eight hours the water becomes cloudy or muddy, it is unfit for domestic use. If it remains perfectly clear it is probably safe to use." — *Health.*

PAGE **220**, § 229 (*a*). **Spring Water.** — "A country house is fortunate if it possesses at a convenient distance a good, cool, copious spring. Nothing is more attractive or more serviceable about a Penn-

[1] First report of Louisiana Board of Health.

sylvania farm than the spring house; often jutting out from a bank or hillside, built low, but firmly, of gray stone, and shaded over by a few old trees. Within you see the clear, transparent pool of water, in its reservoir of stone, pure as the air or sky overhead; and around it, or carefully placed in it, the pans of milk or cream, or butter, waiting for family use. A draught from that supply, flowing out to make a limpid stream through the meadow below, gives more refreshment on a midsummer day than the most tempting beverage of man's contrivance. It has in it no horrors, no mockery, *only health.*" — Dr. Henry Hartshorne, *Our Homes.*

Page **224**, § 233 (*a*). **Purification of Water by Filtering.** — The following *home-made* filter is advised by Dr. Parkes, the eminent sanitarian: "Take a large, common flower-pot, and put into it a bit of zinc gauze or a clean bit of flannel; then coarse gravel to the depth of about three inches; over that the same amount of white sand washed very clean; and next, four inches of charcoal in small fragments, — animal charcoal, when it can be had. On the top of all, a piece of well-cleaned sponge may be placed, making sure that this is changed or thoroughly cleansed once in a week or two — more or less often, according to the impurity of the water."

Page **229**, § 240 (*a*). **Importance of Breathing through the Nose.** — "Air inspired through the nose passes through a refining process, which prepares it for the lungs very much as mastication prepares food for the stomach. If food is improperly masticated, the stomach suffers. If air is improperly refined, the air passages suffer. The *nose* and not the *mouth* was designed as the gateway to the lungs. . . . The mouth may be closed on going to sleep, opened while sleeping, and, when consciousness arrives, closed again, and thus many are ignorant of the fact that they ever breathe through the mouth. If these people are questioned closely, the fact will be elicited that the mouth and throat are always dry in the mornings, and that it may be several hours before this condition wears away. . . . When dryness of the throat is caused by sleeping with the mouth open, if the nasal passages are found to be sufficiently large to supply the lungs with air, the mouth should be kept closed by wearing a skullcap with strings or straps fastened to its sides, which, being tied or buckled under the chin, hold the jaws together." — Dr. Thomas R. French.

Page **241**, § 253 (*a*). **The Results of Re-breathing Expired Air.** — "If you want to see how different the breath breathed out is from the breath taken in, you have only to try a somewhat cruel experiment, but

one which people too often try upon themselves, their children, and their work-people. If you take any small animal with lungs like your own, — mouse, for instance, — and force it to breath no air but what you have breathed already; if you put it in a close box, and, while you take in breath from the outer air, send out your breath through a tube into that box, the animal will soon faint; if you go on long with this process, it will die.

"Take a second instance, which I beg to press most seriously on the notice of mothers, governesses, and nurses. If you allow a child to get into the habit of sleeping with its head under the bedclothes, and thereby breathing its own breath over and over again, that child will, assuredly, grow pale, weak, and ill. Medical men have cases on record of scrofula appearing in children previously healthy, which could only be accounted for from this habit, and which ceased when the habit stopped." — REV. CHAS. KINGSLEY, *Health and Education*.

PAGE **244**, § 258 (*a*). **The Adoption of Prevalent Customs.** — The emigrant "should always adopt any custom which, however new and strange, he finds in use among the settlers of a new country. Those who have preceded him have had the like Saxon unwillingness to adopt a new habit, and have only done so from necessity, the reasons for which may not always be apparent. It is better to fall into it at once, and then seek for its explanation. Especially is this caution necessary in the matter of food. Thus the newly-arrived emigrant in India goes on with his English food, his bottled beer, wine, etc., and is ere long a broken-down, jaundiced creature, whose liver has been ruined, firstly, by the work thrown upon it in accumulation of bile in it in excess, the climate only requiring sparing quantities of food, and, secondly, by the medicine taken to relieve his condition. . . . In travelling, the same thing is seen, though to a less extent than in emigration, and the superior power of adaptation to the wants and requirements of the country explains the health of one person, and the want of it, much of the ill-health of another." — FOTHERGILL, *Maintenance of Health*.

PAGE **253**, § 269 (*a*). **How to Prevent the Spread of Infectious Diseases.** — "The first thought of the parents of a child sick with a communicable disease is one of desire for the child's recovery, and results in the calling in of the family physician. This is eminently the desirable step to take, for the physician is needed to give counsel out of his previous experience with similar cases, and as far as possible to assist nature in the restorative process. But parents and physician must be even more zealous

in considering the welfare of those members of the family who are, up to this time, perfectly well. Properly managed this may be the only case of this disease occurring in this house or in the neighborhood; improperly managed, an epidemic, widespread and dreadful in its ravages, will be the result. Prevention of further extension of the disease should be the watchword now, and the steps taken to bring this about must be prompt and vigorous. Our first suggested practical lesson in sanitary practice is this: Place the sick under the care of the physician and nurse, but be sure that the health officer is allowed to establish conditions such that the disease may be confined to the first case. . . .

"Whenever any case occurs which is suspected to be a dangerous, communicable disease, patient and nurse should at once be isolated from all other persons, those who may themselves be susceptible to the disease, or those who may be the means of communication between the sick and the well. After this, nothing must be allowed to pass from the sick-room to that part of the house occupied by others, until it has been disinfected by proper means. This applies to air, water, food, dishes, clothing, books, papers, — everything that has been within the limits of the sick-room. Isolation must be faithfully applied to all articles of clothing, food, discharges from the body, or other things which become infected. The most extreme care must be taken that all such things shall be thoroughly isolated until they are disinfected.

"Ordinarily it will be the attending physician who will decide whether or not it really is a case of a communicable disease, but immediate steps should be taken even though it is only suspected to be such a case, and the active work of preventing any further spread of the disease should not cease until it is ascertained that it is not such a disease, or until the patient has recovered and the final disinfection is accomplished." — *Teachers' Sanitary Bulletins, Michigan State Board of Health.*

PAGE **254**, § 270 (*a*). **Some Facts about Malaria.** — "Malaria tends to be carried by gentle winds along valleys and level tracts in warm or mild weather. It is much less to be apprehended during the sunshine hours of the day than toward night, although it is reported to rise at times hundreds, or even thousands, of feet up into the air after leaving its place of origin; the rule is that the subtle influence of malaria remains usually within a few feet of the soil, so the nearer one is to the soil the greater the liability to the disease. Accordingly it is safer to have the sleeping room situated more than twelve feet above the surface of the ground, especially if the earth is being dug up. It is best in ague districts not to breath the air near the ground either very early or late in the day. Fires at night

and moderately warm clothing are of service against the infection. Forests tend to intercept this strange poison." — CURRIER, *Practical Hygiene.*

Dr. A. N. Bell, the eminent sanitarian, says that "this poison is a poor sailor, seldom crossing large bodies of water, and is most potent at night. So well do the natives of hot and malarious countries understand this, that at Lake Maracaibo, for example, they sleep at night in their boats on the lake, after their labor through the day on shore, not allowing themselves to stay on the deadly poisonous shore after sunset, or to return to it until after sunrise."

THE VALUE OF THE EUCALYPTUS TREE IN DRAINING WET SOILS. — "That the *E. globulus* has earned by fair experiment its name of fever tree, as a preventive, seems now to be settled. Its rapid growth must make it a great drainer of wet soils, while its marked terebinthine odor may have its influence, and it is highly probable that the liberation of this essence into the air stands connected with its generation of ozone. But whatever the sanatory activities of the eucalypt may be, the fact is squarely settled that spots in Italy, uninhabitable because of malarial fever, have been rendered tolerable by the planting of *E. globulus*, and it is believed that a more plentiful planting would nearly, if not quite, remove the difficulty. A military post is mentioned in Algeria in which the garrison had to be changed every five days, such was the virulence of the malaria. A plantation of eucalypts cleared the miasma nearly away, and rendered unnecessary the frequent changes of the garrison. In this case, sixty thousand trees were planted." — PROF. SAMUEL LOCKWOOD, *Popular Science Monthly*, April, 1876.

PAGE **255**, § 271 (*a*). **The "Black Hole of Calcutta."** — In 1756, one hundred and forty-six English prisoners in Calcutta were confined over night in an apartment about eighteen feet square and fourteen feet high, having but one small window. In the morning, there were alive *twenty-three* only of the strongest, who had been able to get near the window in the struggle that had occurred for fresh air. And of these, nearly all died subsequently of a very low type of typhus fever, known as "putrid fever." The place of their imprisonment has ever since been known as the "Black Hole of Calcutta."

Of the one hundred and fifty passengers shut up in the steamer *Londonderry*, with hatches battened down, during a stormy night in 1848, seventy-two died before morning.

PAGE **255**, § 271 (*b*). **The Air of Bedrooms, Hospital Wards, etc.** — The air escaping from the ventilator of a crowded room is said to be

very offensive, and, if drawn through pure water, will taint it. The air of bedrooms sometimes becomes so contaminated at night that sleep is restless or broken. The admission of a little fresh air will at such times often enable one to sleep soundly. Little children or feeble persons, having passed the night in a close room, are liable in the morning to headache, want of appetite, and a general feeling of debility.

Sometimes hospital wards become absolutely unsafe for patients, through the permeation of the walls, floors, and bedding, with poisonous organic matter. Such wards should be thoroughly cleansed and disinfected. In some instances it has been necessary to replaster the rooms.

PAGE **256**, § 273 (*a*). **Carbon Dioxide in Caves, Wells, etc.** — "Upon the borders of Lake Laacher, near the Rhine, and in Aigueperse, in Auvergne, there are two sources of carbonic acid so abundant that they give rise to accidents in the open country. The gas rises out of small hollows in the ground, where the vegetation is very rich ; the insects and small animals, attracted by the richness of the verdure, seek shelter there, and are at once asphyxiated. Their bodies attract the birds, which also perish. In former times the accidents caused by this gas in caves, mines, and even in wells, gave rise to the most extravagant stories. Such localities were said to be haunted by demons, gnomes, or genii, the guardians of subterranean treasures, whose glance alone caused death, as no trace of lesion or bruise was to be found on the unfortunate persons so suddenly struck down." — CAMMILE FLAMMARION, *The Atmosphere.*

PAGE **257**, § 274 (*a*). **Carbon Dioxide.**

CARBON DIOXIDE IN DWELLINGS, SCHOOLS, ETC. — "The air in a

London schoolroom	contained	29	parts	of	carbonic	acid	in	10,000	of	air,
Munich "	"	72	"	"	"	"	"	"	"	"
Hospital at Madrid	"	43	"	"	"	"	"	"	"	"
Bedroom " "	"	48	"	"	"	"	"	"	"	"
Lecture room at Paris	"	67	"	"	"	"	"	"	"	" "

—DR. HENRY HARTSHORNE, *Our Homes* (*Health Primer*).

A similar excess often exists in our schools, lecture rooms, etc., causing the inmates to be listless and drowsy, and to suffer from headache and faintness. According to Pettenkofer, a man exhales every hour from six tenths to seven tenths of a cubic foot of carbonic acid gas. Angus Smith asserts that a good oil "moderator" lamp produces a little more than half a cubic foot. A common gas burner, consuming three cubic feet of gas per hour, gives off about as much carbonic acid gas as three men in the

same time would do. The light from a good and properly cared for students' lamp, or other reliable lamp, is much better for health, as well as eyesight, than illuminating gas; but if the oil is poor or the wick is turned so low that combustion is imperfect, a poisonous vapor, mixed with floating specks of carbon, diffuses itself through the air, and instances are on record of severe prostration resulting from such impurities.

A SIMPLE TEST FOR CARBON DIOXIDE. — "Dr. Angus Smith's *Household Test for Carbonic Acid Gas* is as follows: Procure a bottle holding ten and a half fluid ounces, fill it with the air of the room you wish to examine, by blowing it in with a bellows or sucking it in through a glass tube pushed down to the bottom of the vial; pour in half an ounce of lime-water, and after corking tightly, shake well for two or three minutes. If, after a short time there is no milky appearance of the lime-water, you may know to a certainty that the ten ounces of air in the bottle do not contain enough carbonic acid to form a visible precipitate of carbonate of lime (chalk) in the lime-water, and this has been proved by careful experiment on a large scale to be equal to less than six hundredths of one per cent of carbonic acid in the sample of air tested; a quantity which has been agreed upon by some high sanitary authorities as the limit beyond which the accumulation of this impurity (and others, perhaps much more noxious, which seem always to accompany it when it arises from human or animal respiration) is injurious to health, and should not be permitted to occur." — DR. J. G. RICHARDSON, *Long Life and How to Reach It.*

PAGE **260**, § 279 (*a*). **Devitalization of Air.**

POISONOUS WALL-PAPERS. — Within the last few years it has been demonstrated by physicians and chemists, both in this country and Europe, that wall-papers (especially those that are roughened, or "flocked," and of a bright green color) are at times poisonous, owing to arsenic substances in the coloring. The arsenic acts as a poison by being diffused in the dust of the rooms, or, as some believe, in a gaseous form as arsenuretted hydrogen, when it may be recognized by a "garlic-like or musty odor." The phenomena of arsenical disease ordinarily produced are similar to those attending a severe cold, viz., an irritation of the eyes and of the lining membrane of the nose and throat. The irritation may extend to the bronchial tubes, lungs, and lower portions of the alimentary canal, or the poison may produce skin eruptions, or may be absorbed in such quantity as to produce convulsions and various disturbances of the nervous system. For further information in regard to poisonous wall-papers, the reader is referred to the investigations made by Dr. Kedzie, as detailed in the *Reports of the Michigan State Board of Health.*

Devitalized Air in Dwellings. — "In many private houses, houses even of the well-to-do and wealthy, streams of devitalized air are nursed with the utmost care. There is the lumber room of the house, in which all kinds of incongruous things are huddled away and excluded from light and fresh air. There are dark under-stair closets in which cast-off clothes, charged with organic debris of the body, are let rest for days or even weeks together. There are bedrooms overstocked with furniture, the floors covered with heavy carpets in which are collected pounds upon pounds of organic dust. There are dressing rooms in which are stowed away old shoes and well-packed drawers of well-worn clothing. There are dining rooms in which the odor of the latest meal is never absent, and from the sideboard and cupboards of which the smell of decomposing fruit or cheese is always emanating, etc. . . . Under such conditions thousands of families live, children grow up, and old people die. They may all go for years and suffer no acute disease, and those of the family whose duty calls them daily into the open air may even be healthy; but those who have to remain nearly all day in the devitalized atmosphere of the home, show the fact in paleness of face, languor of limb, persistent sense of weariness, and dulness of spirit. Under such conditions acute disease, epidemic fever, or other actively dangerous malady need not occur unless it be introduced from without; but the home is ready for it if it be introduced." — Dr. Benjamin W. Richardson, *Diseases of Modern Life.*

Page **260**, § 279 (*b*). **Cleanliness versus Dirt.**—"True cleanliness is a matter of minutiæ, and admits of no subterfuge. If dirt can find a crack, a ledge, or an absorbent surface which cannot be reached by the ordinary method of cleansing, there dirt will accumulate; and where dirt is, there will disease be also. If we are to look to our neighbors for painstaking cleanliness, we must go to Holland for example, where it is popularly believed that no gastronomic injury would ensue from dining directly off the flooring boards or tiles. Beyond the delightful duty of scrubbing everything which is not painted, the Dutchman and his wife find no such esoteric and sanitary delight as in painting everything which cannot be scrubbed or rubbed bright. And the Dutchman is right. No layer upon layer of paper-hangings, with brown, gray, or green arsenical dust to slowly poison the more susceptible of the family. No sham plaster walls, porous to sewer-gas and corrupted with putrefied paste, can be allowed. If we have lath and plaster, let it be painted; and if we cannot have wainscot or mahogany, kept brilliant by continual cleanly friction and polish, let us have a clean, painted, wooden surface, as artistic in tint and in the disposal of the colors and decoration as taste

and means will afford it; but, to carry out a determined war against dirt and disease, let us have paint. These are no longer notions peculiar to the Dutch. They are sanitary axioms, which we cannot afford to ignore." — DR. H. C. BARTLETT, Paper on *Chemistry of Dirt.*

PAGE **260**, § 280 (*a*). **Dr. Richardson on Damp Air in Houses.** — "It is not invariably the new house that is rendered dangerous by being damp. There are in this country many old houses, picturesquely situated, which are not less dangerous. The stranger passing one of these residences is struck by its beauty. There is the ancient moat around it, or the lake in front with the sailing boat and swans, the summer-house, and splendid trees down to the water's edge. The stranger may well enough be fascinated by the view, but let him inquire and he will too often find a truly ghostly history of the place. He will be told, probably with some exaggeration of the truth, that the house is unlucky, that no one who has lived in it has reared a healthy child, and that a traditional malediction taints the place. If he enter the house he finds the basement steaming with water vapor; walls constantly bedewed with moisture; cellars coated with fungus and mould; drawing-rooms and dining rooms always, except in the very heat of summer, oppressive from moisture; bedrooms, the windows of which are, in winter, often so frosted on the inner surface from condensation of the water in the air of the room, that all day they are coated with ice. The malediction on the young nurtured in that mansion may not be so deep as is rumored, and it is much less obscure than is imagined; but it is there, and its name is 'damp.'" — DR. BENJAMIN W. RICHARDSON, *Diseases of Modern Life.*

PAGE **262**, § 281 (*a*). **Condition of Ordinary Tenement Houses.** — "This is the place: these narrow ways diverging to the right and left, and reeking everywhere with dirt and filth. Such lives as are led here bear the same fruit here as elsewhere. The coarse and bloated faces at the doors have counterparts at home and all the wide world over. Debauchery has made the very houses prematurely old. See how the rotten beams are tumbling down, and how the patched and broken windows seem to scowl dimly, like eyes that have been hurt in drunken frays. . . . What lies beyond this tottering flight of steps that creak beneath our tread? A miserable room lighted by one dim candle, and destitute of all comfort, save that which may be hidden in a wretched bed. Beside it sits a man; his elbows on his knees; his forehead hidden in his hands. 'What ails that man?' asks the foremost officer; 'Fever,' he sullenly replies, without looking up. Conceive the fancies of a fevered brain in such a place as this!" — CHARLES DICKENS, *American Notes.*

"When the great riot occurred in 1863, every hiding-place and nursery of crime discovered itself by immediate and active participation in the operations of the mob. Those very places and domiciles, and all that are like them, are to-day nurseries of crime. . . . By far the largest part — eighty per cent at least — of the crimes against property and against the person are perpetrated by individuals who have either lost connection with home life or never had any, *or whose homes had ceased to be sufficiently separate, decent, and desirable to afford what are regarded as ordinary wholesome influences of home and family.* Pure air, pure light, and sufficient room for domestic privacy and purity, are the simple remedies for these evil conditions." — *Report of Tenement House Committee*, New York.

"A fire in the night in one of these human beehives, with its terror and woe, is one of the things that live in the recollection ever after as a terrible nightmare. . . . A more unlovely existence than that in one of these tenements it would be hard to imagine. Everywhere is the stench of the kerosene stove that is forever burning, serving for cooking, heating, and ironing alike, until the last atom of oxygen is burned out of the close air. Oil is cheaper than coal. The air shaft is too busy carrying up smells from below to bring any air down, even if it is not hung full of washing in every story, as it ordinarily is. Enterprising tenants turn it to use as a refrigerator as well. There is at least a draught of air, such as it is. . . . The stuffy rooms seem as if they were made for dwarfs. Most decidedly, there is not room to swing the proverbial cat in any one of them. . . . The original demand was for 600 cubic feet of air space for each adult sleeper. . . . But of 28,000 and odd tenants canvassed in New York, in the slumming investigation prosecuted by the general government in 1894, 17,047 were found to have less than 400 feet, and of these 5526 *slept in unventilated rooms with no windows.* . . . Uptown or downtown, as the tenements grow taller, the thing that is rarest to find is the home of the olden days, even as it was in the shanty on the rocks. 'No home, no family, no morality, no manhood, no patriotism!' said the old Frenchman. Seventy-seven per cent of their young prisoners, say the managers of the state reformatory, have no moral sense, or next to none. 'Weakness, not wickedness, ails them,' adds the prison reformer." — JACOB A. RIIS, *The Tenement House Blight.*

PAGE **262**, § 281 (*b*). **The Need of Model Tenements.** — "The persistence of sickness and mortality in the old, crowded, tenement dwellings of our city, and the rapid and very great falling off in the rates of sickness and death in the new and airy sanitary dwellings like Sir

Sydney Waterlow's in London, and Mr. White's in Brooklyn, or like the improved districts in Edinburgh and Glasgow, show that a great work for the physical and moral improvement of the common classes, and for the prevention of poverty and causes of pauperism, must be undertaken in plans for dwelling reform in our crowded city. The homes of the New York City poor must be provided with sunlight, fresh air, and the moral safeguards of real domesticity. The Improved Industrial Dwellings Company, of which Sir Sydney Waterlow is president, in London, report that in their nearly three thousand tenements there are no fevers and deaths by contagious diseases, and in Glasgow the health officer reports that in the reformed dwellings he has not heard of a case of infectious disease. Let the deadly contagion of vices and crimes be exterminated from the habitations of the poor, and let the natural agencies of health and purity surround and fill their dwellings, as means of saving from pauperizing, sickness, and from the evils that medical charities and penal institutions cannot cure."

GOOD RESULTS OF IMPROVED DWELLINGS. — Improved buildings in Brooklyn, built by Mr. A. T. White after the best London models, contain from one thousand to eleven hundred people. In the city of Brooklyn at large, the annual deaths of children under five appear to average between nine and ten in the hundred, while in these dwellings it is only between six and seven, according to the agent's figures. In old-style tenements of about the same size in New York, the Board of Health figures show a corresponding rate of 11.4.

It appears from the death records in these Brooklyn buildings that "there is no instance in which a contagious disease has been communicated to apartments adjoining, or above or below. These diseases, of course, enter there, as into the best-guarded private houses, but the outside staircase has so far provided all necessary isolation, while in ordinary houses used by several families the stairway hall is as natural a vehicle for the communication of disease as that of sound, smells, or flames." — ALFRED T. WHITE, *Dwellings of the Laboring Classes.*

PAGE **262**, § 282 (*a*). **Living in the Open Air.** — Dr. Benjamin Ward Richardson, of London, who has studied the condition of the homeless, divides them into three classes: first, vagrants; second, itinerants, like the "cheap John" fraternity and showmen; and third, nomads, like the gypsies. He says: —

"The vagrant class, notwithstanding irregular meals, uncertain lodgings, and general lack of comfort, enjoy a degree of health equal, at least, to that of the hard-working classes in packed communities. They do not

suffer from any special class of diseases, and zymotic diseases are not specially prevalent among them. Generally they do not live to a great age, but there are exceptions to this rule.

"The itinerant class is much better fed and clothed than the vagrant class, and much better sheltered apparently, yet the close van, which serves at once for storehouse, kitchen, sitting-room, and sleeping apartment, does not conduce to the health and well-being of its inmates. They are not healthy looking, and their children have usually a pale and oppressed cast. They seem to be less subject to such diseases as measles, scarlet fever, smallpox, and typhoid fever, than residents of houses are.

"The nomadic class, or tent-dwellers, are by far the most fortunate in regard to health. Rheumatism of the subacute or chronic variety, without fever, seems to be their only enemy in the way of disease. Of the zymotic diseases they know little. They do not suffer from consumption nor any of the chest diseases. . . . These statements apply only to gypsies in the nomadic state. When they settle down to the happier (?) influences of civilization, such comforts as consumption, zymotic diseases, chest diseases, etc., come within their reach. . . . Poverty, of itself, is not necessarily a cause of the worst diseases. Open air is a powerful disinfectant, protecting the gypsy from germs which we vainly fight with all the aid of science.

"In many human habitations diseases are not only begotten, but entrapped."

PAGE **265**, § 286 (*a*). **The Passage of Air through Plaster, Bricks, etc.** — "My illustrious preceptor, Prof. John W. Draper, demonstrated, many years since, by a series of ingenious experiments, the facility with which gases diffuse, even when opposed by a pressure equivalent to that of twenty atmospheres. The illustrations exhibited this evening warrant us in the deduction that the purity of air in our buildings, whether private or public, is due not only to ventilation and to the imperfect work of the carpenter, but also to the porosity of the plaster, and the brick or stone walls through which *diffusion* takes place, a part of the foul air within being exchanged for the fresh, oxygen-abounding air from without." — DR. R. OGDEN DOREMUS.

PAGE **265**, § 286 (*b*). **Automatic Ventilation.** — As an instance of automatic ventilation, may be mentioned the plan in use in the cabins of the ferry-boats plying between New York and Brooklyn. These boats carry thousands of persons every week. Before the introduction of the automatic ventilators, the air of the cabins, at times of day when the passengers were most numerous, was stifling and impure. Since their

use, a very perceptible change for the better has been noticed. The following are sometimes the results of non-automatic ventilation: In an institution for children the ventilators were open upon the doctor's visit, but a few moments after were found filled with old clothes. In a large school, where the air was impure and the cause of sickness, an investigation showed that the ventilating apparatus, though in itself good, was of no real value, for the janitor used the fresh-air flue of the furnace as a chicken coop, and the janitor's boy the ventilator in the roof as a pigeon house.

PAGE **266**, § 287 (*a*). **The Amount of Air required in Ventilation.** — "The only safe principle in dealing with the subject is to have a large margin for contingencies; and the question really is not whether six hundred cubic feet per man is too much but whether six hundred cubic feet per man be enough for all the purposes of warming, ventilation, and comfort. It has been said that the question of cubic space is simply a question of ventilation, but it is rather a question as to the possibility of ventilation. The more beds or encumbrances you have in a room with a limited cubic space, the more obstruction you have to ventilation. The fewer the beds, the more easy it is to ventilate the rooms. There are fewer nooks and corners, fewer surfaces opposed to the movement of the air, and less stagnation." — *Report of Barracks Improvement Commission.*

PAGE **267**, § 288 (*a*). "**Instructions for Disinfection** (*prepared for the National Board of Health*). — Disinfection is the destruction of the poisons of infectious and contagious diseases. Deodorizers, or substances which destroy smells, are not necessarily disinfectants, and disinfectants do not necessarily have an odor. Disinfection cannot compensate for want of cleanliness, nor of ventilation.

"I. DISINFECTANTS TO BE EMPLOYED. — (1) Roll sulphur (brimstone) for fumigation. (2) Sulphate of iron (copperas) dissolved in water in the proportion of one and a half pounds to the gallon: for soil, sewers, etc. (3) Sulphate of zinc and common salt, dissolved together in water in the proportions of four ounces sulphate and two ounces salt to the gallon: for clothing, bed linen, etc.[1]

[1] Carbolic acid is not included in the above list, for the following reasons: It is very difficult to determine the quality of the commercial article, and the purchaser can never be certain of securing it of proper strength; it is expensive, when of good quality, and experience has shown that it must be employed in comparatively large quantities to be of any use; it is liable by its strong odor to give a false sense of security.

"II. How to use Disinfectants. — (1) *In the Sick-room.* — The most available agents are fresh air and cleanliness. The clothing, towels, bed-linen, etc., should, on removal from the patient, and before they are taken from the room, be placed in a pail or tub of the zinc solution, boiling hot, if possible. All discharges should either be received in vessels containing copperas solution, or, when this is impracticable, should be immediately covered with copperas solution. All vessels used about the patient should be cleansed with the same solution. Unnecessary furniture, especially that which is stuffed, carpets and hangings, should, when possible, be removed from the room at the outset; otherwise they should remain for subsequent fumigation and treatment. (2) *Fumigation* with sulphur is the only practicable method for disinfecting the house. For this purpose the rooms to be disinfected must be vacated. Heavy clothing, blankets, bedding, and other articles which cannot be treated with zinc solution, should be opened and exposed during fumigation, as directed below. Close the rooms as tightly as possible, place the sulphur in iron pans supported upon bricks placed in wash-tubs containing a little water, set it on fire by hot coals or with the aid of a spoonful of alcohol, and allow the room to remain closed for twenty-four hours. For a room about ten feet square, at least two pounds of sulphur should be used; for larger rooms, proportionally increased quantities. (3) *Premises.* — Cellars, yards, stables, gutters, privies, cesspools, water-closets, drains, sewers, etc., should be frequently and liberally treated with copperas solution. The copperas solution is easily prepared by hanging a basket containing about sixty pounds of copperas in a barrel of water. (4) *Body and Bedclothing, etc.* — It is *best* to burn all articles which have been in contact with persons sick with contagious or infectious diseases. Articles too valuable to be destroyed should be treated as follows: (*a*) cotton, linen, flannels, blankets, etc., should be treated with the boiling hot zinc solution; introduce piece by piece, secure thorough wetting, and boil for at least half an hour. (*b*) Heavy woollen clothing, silks, furs, stuffed bed covers, beds, and other articles which cannot be treated with the zinc solution, should be hung in the room during fumigation, their surfaces thoroughly exposed, and pockets turned inside out. Afterward they should be hung in the open air, beaten and shaken. Pillows, beds, stuffed mattresses, upholstered furniture, etc., should be cut open, the contents spread out, and thoroughly fumigated. Carpets are best fumigated on the floor, but should afterward be removed to the open air and thoroughly beaten. (5) *Corpses* should be thoroughly washed with a zinc solution of double strength; should then be wrapped in a sheet wet with the zinc solution, and buried at once. Metallic, metal-lined, or air-

tight coffins should be used when possible; certainly when the body is to be transported for any considerable distance.

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The Committee on Disinfectants of the American Public Health Association give the following conclusions as to the value of various disinfectants in the order named: —

CONCLUSIONS.

Agents for the Destruction of Spore-containing Infectious Material.

1. Fire, complete destruction by burning.
2. Steam under pressure, 105° C. (221° F.) for ten minutes.
3. Boiling water for half an hour.
4. Chloride of lime,[1] a four per cent solution.
5. Mercuric chloride, a solution of one to five hundred.

Agents for the Destruction of Infectious Material not containing Spores.

1. Fire, complete destruction by burning.
2. Boiling in water for ten minutes.
3. Dry heat, 110° C. (230° F.) for two hours.
4. Chloride of lime, a two per cent solution.
5. Solution of chlorinated soda,[2] a ten per cent solution.
6. Mercuric chloride, a solution of one to two thousand.
7. Carbolic acid, a five per cent solution.
8. Sulphate of copper, a five per cent solution.
9. Chloride of zinc, a ten per cent solution.
10. Sulphur dioxide,[3] exposure for twelve hours to an atmosphere containing four volumes per cent of this gas in presence of moisture.

PAGE **267**, § 289 (*a*). **Light as a Stimulus to Respiration.** — "It has been an axiom from time immemorial that for health sleep should be taken during the still hours of night, and not during the day. The

[1] Containing at least twenty-five per cent of available chlorine.

[2] Containing at least three per cent of available chlorine.

[3] This will require the combustion of between three and four pounds of sulphur for every one thousand cubic feet of air space.

example of the ruddy, healthy peasant, who retires to rest with his cattle, and is up with the lark, has been quoted a thousand times. It appears to me, however, that the undeniable fact of exposure to the light of day being an element of health which vivifies and reddens the blood was never satisfactorily explained until the publication of the experiments of the late Dr. Edward Smith, of the Brompton Hospital. Dr. Smith has proved that light is a powerful stimulus to respiration; that under the influence of daylight one third more atmospheric air enters the lungs than under darkness, or even under exposure to artificial light. In other words, if in daylight during a given time six hundred cubic inches of atmospheric air were inspired, during the same time at night only four hundred would enter the lungs, — a powerful additional reason and argument for pure air at night during sleep. As the oxygenation and subsequent reddening of the blood depend on its contact with atmospheric air in the lungs during respiration, it is clear, if we accept the above statements, that the more the body is exposed to sunlight the more oxygen it will imbibe. As a necessary sequel, the more oxygen physiologically enters the economy, through the functions of respiration, the more perfectly will all the vital processes which require oxygen be performed." — BENNETT, *Nutrition in Health and Disease.*

PAGE **268**, § 289 (*b*). **Light as a Destroyer of Disease Germs.** — "Among the germicide agents which have been tested, I will first mention *light.* We have experiments by a number of different observers upon the germicide power of light, and it is a very interesting fact that exposure to the bright sunlight destroys pathogenic organisms, independent of the heat of the sun; experiments have been made to show this. Taking two tubes, one of which is enveloped in tinfoil to exclude the light, but which receives the heat in the same way as the other; in the one which is exposed to the bright sunlight the germs in certain cases are destroyed — in some instances in quite a short time. Duclaux found that certain micro-organisms are destroyed in twelve hours' time when exposed to the sun during June and July. He found that dry spores were destroyed in two months when exposed in a dry condition. These spores can be kept indefinitely when put in a dark place in a dry condition. Another observer, Arloing, found that the spores of anthrax in bouillon were killed in two hours; whereas the anthrax bacillus required from twenty-seven to thirty hours. It was a strange fact that the anthrax bacilli which had grown out withstood the light longer than the spores. The explanation is supposed to be that the spore, just at the moment of sprouting, is more tender and more easily killed than the bacilli after they are in full devel-

opment and multiplying by binary division. He found by putting these same spores in water that they were not killed; it was only in a suitable culture medium that the light had this effect on them. By the electric light spores in bouillon were killed in one hour. This shows us that in sunlight we have a sanitary agent of great importance; a fact which has long been recognized by sanitarians, and now we have experimental data to support this well-recognized fact." — Dr. G. M. Sternberg.

Page **274**, § 295 (*a*). **Nerve Cells.** — "The cell of the nervous tissue, like that of all other tissues, is the essential, living part. In it go on the mysterious molecular changes which are presented to us as nervous action. To it the surrounding structures are entirely subservient. It is the textural Rome to which all roads turn. It is upheld by the connective tissue; it is nourished by the capillaries and lymphatics; it is drained by the venules. Although it differs from other cells in many ways that are strongly marked, in none is it more distinctive than in the fact that it is placed in direct, or almost direct, communication with distant structures by fibres that conduct sensations *to* it and by others that convey actions *from* it. The type of a nervous organism, then, is a cell, to which are attached conducting fibres for sensation and motion respectively. The cells being clustered together in what is known as gray matter, and the conducting fibres being composed of so-called white matter, all nervous structures are made up of gray or cellular and white or conducting matter, be the relative proportions of each, and the form of the particular organ, what they may. Each group of cells — perhaps the science of the future will enable us to say each cell — has an intelligence of its own, which has long been beclouded by the name of 'function.' This intelligence, misnamed function, is adequate to the purpose of that particular group of cells. If they be the cells of a jellyfish, they enable the animal to float on the surface of the water, to nourish itself, and to seize its prey. If they be the cells of a bee, they enable it to organize all the wondrous economy of the hive, — to select its queen, to eliminate the drones, to build the mathematical cell. If they be the cells of the lion, they form the anatomical substratum of all the beast's kingly and ferocious habits. Finally, when they become the cells of the human gray matter, they are intelligent still, varying in the degree of that intelligence as it mounts from the lowly lower end of the spinal cord, increasing in complexity as it ascends, until it culminates in the most wonderful gray matter of all species, — the cortex of the cerebrum, the seat of the mind.

"From the foregoing statements it follows that all nervous organisms are composed of numerous foci of cellular intelligence, intercommunicating

and bound together into one harmonious whole by the white or conducting fibres." — DR. LANDON CARTER GRAY, in the *Annals of the Anatomical and Surgical Society.*

PAGE **280**, § 303 (*a*). **The Weight of the Brain.** — "The average male brain (in Europeans) is 49.5 oz.; the female, 44 oz. The brain of Cuvier, the naturalist, weighed 64.5 oz., and that of Daniel Webster, 53.5 oz. The brains of idiots have been found to vary in weight from 27 oz. to as low as 8.5 oz. The brains of the insane are said to be 2½ per cent below the average of the sane. Tall men, as a rule, have larger brains than small men. . . . The maximum size of the brain is reached, not in human beings, but in the elephant tribe; and after, the whales, whose ponderous bodies demand an enormous muscular expenditure. The elephant's brain weighs from 8 to 10 lbs.; the whale's brain is said to weigh from 5 to 8 lbs. . . . In addition to the propulsion of the muscles, a considerable amount of nerve force must be expended in supporting or aiding the processes of organic life, — digestion, respiration, circulation, and other operations." — BAIN, *Mind and Body.*

PAGE **283**, § 307 (*a*). **The Brain Working of Men and Women.** — "We doubt whether woman is necessarily and essentially inferior mentally to man; we are quite sure she is mentally dissimilar. The great maternal function alone could not operate without gradually inducing intellectual differences which are perpetuated by sexual transmission. All experience tends to show that woman shines in intuition, man in judgment; that woman is strongest when impelled by emotion, man when impelled by will; that man is creative, woman administrative; that woman is greatest in self-sacrifice, man in conquest and achievement. Be these differences inherent in sex, or the outcome of evolution, their experience can hardly escape any observer who does not start with some preconceived theory."

PAGE **283**, § 308 (*a*). **The Development of the Brain in Children.** — "Between the fifth and sixth years the base of the brain grows very rapidly; the frontal bone protrudes anteriorly and grows upward. The anterior portion grows considerably, but still the white substance and middle portion of brain are prevalent. These are the organs for the receptive faculties and memory. About this time learning ought to commence in earnest. All the above figures point to the end of the seventh year as the period of beginning mental work. But the gray substance is also developing at that period. It ought to be influenced to a certain degree, like a young tree in the time of its growth, without, how-

ever, being strained. Many organs in the brain, — many functions. Neglect none; exercise all gently. It is a mistake to exercise one faculty only. Our text-books, in the shape of catechisms, exercise the memory only, and thereby fatigue and exhaust. The compound exercise consisting in walking, with its changes and coöperative action, is less fatiguing than standing on a single leg. Learning by heart is not learning, and reciting is not thinking; just as little as deglutition is digestion." — DR. A. JACOBI, *Transactions N. Y. Academy of Medicine.*

PAGE **306**, § 331 (*a*). **How the Nervous System is injured by Overwork.** — "You see, my dear working friends, I am great upon sparing your strength and taking things cannily. 'All very well,' say you, 'it is easy speaking, and saying "Take it easy"; but if the pot's on the fire, it maun bile.' It must; but you needn't poke up the fire forever, and you may now and then set the kettle on the hob and let it sing, instead of leaving it to burn its bottom out. I had a friend who injured himself by overwork. One day I asked the servant if any person had called, and was told that some one had. 'Who was it?' 'Oh, it's the little gentleman that *aye rins when he walks!*' So I wish this age would walk more, and 'rin' less. A man can walk farther and longer than he can run, and it is poor saving to get out of breath. . . . I am constantly seeing men who suffer, and indeed die, from living too fast; from true, though not consciously, immoral dissipation, or scattering of their lives. Many a man is bankrupt in constitution at forty-five, and either takes out a *cessio* of himself to the grave, or goes on paying ten per cent for his stock in trade; he spends his capital instead of merely spending what he makes, or, better still, laying up a purse for the days of darkness and old age. A queer man, forty years ago, Mr. Slate, or, as he was called, *Schlate*, — who was too clever and not clever enough, and had not wisdom to use his wit, always scheming, full of 'go' but never getting on, — was stopped by his friend, Sir Walter Scott (that wonderful friend of us all, to whom we owe Jeanie Deans and Rob Roy, Meg Merrilies and Dandie Dinmont, Jinglin' Geordie, Cuddie Headrigg, and the immortal Bailie), one day, in Princess Street. 'How are ye getting on, Schlate?' 'Oo, just the auld thing, Sir Walter, *ma pennies a' gang on tippenny eerands.*' And so it is with our nervous power, with our vital capital, with the pence of life, — many of them go on 'tippenny eerands.' We are forever getting our bills renewed, till down comes the poor and damaged concern with dropsy or consumption, blazing fever, madness, or palsy." — DR. JOHN BROWN, *Spare Hours.*

PAGE **306**, § 332 (*a*). **Wear and Tear of the Body.** — "I have called these hints *Wear* and *Tear*, because this title clearly and briefly

points out my meaning. *Wear* is a natural and legitimate result of lawful use, and is what we all have to put up with as the result of years of activity of brain and body. *Tear* is another matter; it comes of hard or evil usage of body or engine, of putting things to wrong purposes, using a chisel for a screw-driver, a penknife for a gimlet. Long strain, or the sudden demand of strength from weakness, causes tear. Wear comes of use, tear of abuse. . . . Why is it that an excess of physical labor is better borne than a like excess of mental labor? The simple answer is, that mental overwork is harder, because, as a rule, it is closet, or counting room, or, at least, indoor, work, — sedentary, in a word. The man who is intently using his brain is not collaterally employing any other organs, and the more intense his application, the less locomotive does he become." — Dr. S. Weir Mitchell, *Wear and Tear*.

Page **306**, § 332 (*b*). **Hysteria and Nervousness.**

The Causes and Evils of Hysteria. — The term *Hysteria* is ordinarily applied by the laity to alternating conditions of the emotions; among medical writers, it refers to various phenomena of disturbed nervous force. It can simulate every known disease. The emotional variety, while it may be the result of incipient disease of the nervous system or some other part of the body, of overwork, or of worry, is too often due to the concentration of one's thoughts upon one's self, the desire for notoriety, etc. If hysteria is merely "a bad habit," it should be broken up, not only for the welfare of the individual afflicted, but because impressible friends may acquire similar habits, by imitation. The cure consists in a change of surroundings (of habitation, companions, etc.) and in hygienic measures. If the hysteria is the result of disease, it needs the best medical aid, for it is then a serious affection. Dr. S. Weir Mitchell, in speaking of the fact that men as well as women are liable to hysteria says: "I have many a time seen soldiers who had ridden boldly with Sheridan or fought gallantly with Grant, become, under the influence of painful nerve wounds, as irritable and hysterical as the veriest girl." In reference to the bad influences which hysterical persons exert, he writes truthfully: "A hysterical girl is, as Wendell Holmes has said in his decisive phrase, a vampire who sucks the blood of the healthy people about her, and I may add that pretty surely where there is one hysterical girl, there will be soon or late two sick women."

What ails the Modern Girl? — "The modern girl hardly knows what she wants, whether it is the higher education, an æsthetic wardrobe, love, or fame. She plays tennis and progressive euchre, and flirts and does Kensington work and reads Herbert Spencer, and very often writes; she

dabbles in music and talks theosophy, and if there are more things in heaven and earth than are dreamed of in her philosophy one questions what they can be. Withal, she is as restless as the wind. She does not love the quiet of home; she lives on excitement; she goes to Europe, to the springs, the mountains, the theatres, the receptions, if she can get there, or to the modiste; she can always fall back upon clothes as a diversion, and, when everything else fails, she has nervous prostration and a trained nurse. In fact, the chief trouble with the modern girl, be she rich or poor, is that she either does too much, keeps her nerves on the strain, and by and by goes to the other extreme, and does literally nothing but consume drugs, talk of her ills, and consult the Christian Scientists; or she has no real interests, fritters away her time in shallow pursuits, becomes pessimistic and dyspeptic, dissatisfied with herself and all the world; cries and questions if life is worth living, and feels especially blue on holidays. The remedy for all this is, perhaps, an object in life; those who are well and unselfishly occupied do not question if life is worth living; they know it is; and whether they are busy in the shoe factory, behind a counter, at the fireside, in the kitchen or the dining room, so long as they are busy and not shirking or reaching forward for something more congenial, and neglecting present duty, their minds are at rest and uninvaded by despondency. One of the best remedies for depression of spirits is the effort to bestow happiness; it has been known to prove effectual when all other methods have failed; when novels and new gowns and cod-liver oil and bovinine and bromide, when admiration and flattery, are no more serviceable than an abracadabra or any heathen spell. Melancholy or other ills of this nature are the direct result of a too strong egotism; and an absorbing interest in others is a safe and agreeable medicine and is usually the last thing a modern girl tries." — *Boston Medical and Surgical Journal.*

PAGE **316**, § 341 (*a*). **Keenness of the Senses.** — "It seems to be a rule — one to which perhaps there are exceptions, and yet a rule — that when we suffer the loss or very serious impairment of one sense, nature compensates us by sharpening some other. Of this many interesting examples are seen.

"Sanderson, the mathematician, lost his sight in 1683, when only one year old, after a severe attack of the smallpox. But in spite of his complete blindness, he gave himself up to the assiduous study of the sciences, and finally lectured at the University of Cambridge on mathematics and optics, with wonderful success. His sense of touch was exquisitely fine; thus, in a collection of Roman medals, he could distinguish the genuine

from the false, although the latter were often so admirably counterfeited as to deceive those who examined them with their eyes. By the different feeling of the air on the face, he could tell when an object was placed before him, and his hearing was so accurate, in seizing and appreciating the slightest sounds, that he could determine the height of any chamber into which he was introduced, and his distance from the wall."

PAGE **322**, § 351 (*a*). **What the Sense of Smell does for us.**— "Of all our senses, smell is the one that soonest gets out of practice, so much so that numbers of people really do not perceive disagreeable smells at all. If they always accustomed themselves to take notice, and to use their noses, they never would consent to live in the horrid air they do. That is a grand use of the sense of smell. It tells a person who attends to it, that there is some bad or injurious thing mixing itself in the air. A sensible person then sets to work to get rid of that thing, whatever it may be, and to make his air clean again. A stupid person takes no notice, and then his nose gets used to the disagreeable smell, and leaves off perceiving it." —J. BERNERS, *Lessons on Health.*

PAGE **324**, § 353 (*a*). **Odors.** — "It is well known that perfumes from very different sources may be classed under certain types. Thus the rose type includes geranium, eglantine, and violet ebony; the jasmine type, lily of the valley and ylang-ylang; the orange type, acacia, syringa, and orange flower; the vanilla type, balsam of Peru, benzoin, storax, tonka bean, and heliotrope; the lavender type, thyme and marjoram; the mint type, peppermint, balsam, and sage; the musk type, musk and amber seed; and the fruity type, pear, apple, pineapple, and quince. Attempts have been made to discover a relation between the colors of flowers and the intensity of their perfumes. White flowers manifest the greatest variety of odors, and then follow reds, yellows, greens, and blues. . . . It is also noticeable that flowers which by their color emit most heat will volatilize the greatest amount of perfume, and that the more refrangible the rays reflected from the flower, the smaller is the amount of perfume. Colored substances have also different powers of absorbing odors. Whites, yellows, reds, greens, and blues absorb odors on a decreasing scale. The more intense the color the more likely is it to emit a strong odor, because no doubt the light acts on the essential oil on which the odor depends. Heat, more than light, favors the volatilization of perfumes. Hence the odors of a flower bed in a garden are often most apparent, not in bright sunshine, but in the shade. . . . An air of moderately high temperature and the presence of moisture favor the diffusion

of the odors of most flowers." — DR. JOHN GRAY MCKENDRICK AND WM. SNODGRASS, *The Physiology of the Senses*, Glasgow.

PAGE **338**, § 368 (*a*). **The Importance of the Convergence of the Eyes in Vision.** — "To direct both eyes to the same point requires a delicately balanced associated action of several muscles of each eye. In any part of the body, where a certain set of muscles are accustomed to act together in a given direction, this particular combination of movements becomes natural and easy, and any other comparatively difficult. This may be appreciated, for instance, by any one who has undertaken to drive a nail into the ceiling, and has experienced the fatigue of the muscles of the arm and neck and back that follows almost immediately. We are accustomed always, in converging the eyes towards any small object, at the same time to direct them downwards, as the object is usually held in the hand, or lies on something before us, below the level of the eyes. This facility of turning both eyes inwards and downwards at the same time has not only been acquired by the individual, but has been inherited from his ancestors, and has become a part of his nature; so that the association of convergence with any other than a downward movement demands an extraordinary effort. This is a cause of fatigue in looking at pictures hung high in a gallery. Considerable interest has been excited recently by an affection noticed in miners, and called 'miner's nystagmus,' in which the external muscles of the eyeball seem to lose their balance, and the eyes continually oscillate. It is thought to result from the unnatural position of the eyes, in working at the roof of the subterranean cavern in which these men pass their lives." — *Eyesight and How to Care for It (American Health Primer)*.

PAGE **343**, § 372 (*a*). **Test for Color-blindness.** — In several countries, at the present day, all railroad engineers, pilots, switchmen, etc., are tested as to color-blindness. From some examinations made by Dr. Jefries, of Boston, he concludes that about one person in every twenty-five is color-blind, and that color-blindness is much less frequent among women than among men. It can be readily tested in schools.

"The most efficient test is the wool test of Holmgren, which consists of three skeins of wool dyed with *standard test colors*, viz., a light green, a pale purple or pink, and a bright red. Other skeins of reds, oranges, yellows, yellowish greens, pure greens, blue greens, violets, purples, pinks, browns, and grays, all called *confusion colors*, are provided, and the examiner is requested to select one, and match it with one of the test colors. Suppose the light green skein is shown first. If the examiner

matches grays, brownish grays, yellows, orange, or faint pink with this he is color-blind. Then he is shown the purple skein. If he matches with this blue or violet he is red-blind, but if he selects only gray or green he is green-blind. Finally, he may be shown the red skein, having a bright red color, like the red flag used on railways. A red-blind person will then match, with this, green or shades of brown which to a normal eye seem darker than red, while if he be green-blind he will select shades of these colors which look lighter than red. Violet-blindness is recognized by the examiner confusing red and orange with purple." — *Physiology of the Senses.*

PAGE **344**, § 373 (*a*). **The Disadvantages of Short Sight.** — Short sight is said to be found seldom among farmers, seamen, and Indians, but it is very common in large cities among students, engravers, artists, etc., especially if they work by a flickering light, or one that shines brightly from in front directly upon the work. From an examination of the eyes of pupils between six and twenty-one years of age, in various schools throughout the country, by Drs. E. G. Loring, R. H. Derby, A. R. Mathewson, and J. S. Prout, it has been ascertained that among the lower classes 3.5 per cent were near-sighted, and among the higher 26⅞ per cent. In Germany the percentages are said to be even greater; and it is rare to find army officers who do not wear spectacles. It may be that if as large a proportion of persons in this country with optical defects should wear glasses as is the case in Germany, we should be considered as equally near-sighted.

"A child may be thought a dullard, and to have no aptitude for observation or learning; he may be counted cold-hearted and unresponsive when his face does not light up at the smile of his mother or the caress of his sister; he may be esteemed sullen or stupid; he may be counted a bad playfellow; he may be thought eccentric or peculiar, because he does not behave like other children. All this and more may be the character ascribed to him, because his misfortune is to have bad sight. Besides this, it is a truth in mental philosophy, that exactly such a character may be fastened upon him for life, because in his young days he was cut off from enjoyment of the visible world on terms of equality with his fellows. Do we not know that dim-sighted persons are apt to be queer? If their deficiencies had been noted and corrected at an early stage of life, who can say how much more symmetrical would have been their adult character, and how much happiness society and the family might have enjoyed from them?" — PROF. H. D. NOYES, of New York, *Eye Troubles in General Practice.*

PAGE **346**, § 378 (*a*). **Injurious Effects of Certain Occupations upon the Eyesight.** — "The knowledge of the injurious effects of certain kinds of schooling upon vision is not a new acquisition; for Beer wrote, more than sixty years ago, 'He who has taken the fruitless pains as often as I have, to try and impress upon parents and friends, in the most friendly manner and upon the most convincing grounds, the mischievous effect upon the eyes of growing children of the forcing-house system of the present day, will still be disheartened to find his well-intended counsel, based upon long experience, and often repeated, either entirely neglected, or listened to only by a few.' . . . Because people hold the imperfectly understood principle that children should be constantly occupied, there is at all hours of the day a master at hand. There is reading, writing, language-learning, drawing, arithmetic, embroidery, singing, piano and guitar playing without end, until the persecuted victims are rendered pale, weak, and sickly, and to such an extent short-sighted or weak-sighted that finally counsel must be obtained. . . . Of what avail is it to many charming girls, many estimable women, that as children they were regarded as prodigies, when the soundness of their eyes and the acuteness of their vision have been sacrificed?" — R. B. CARTER, *Eyesight, Good and Bad.*

PAGE **347**, § 378 (*b*). **Printing Suitable for the Eyes.** — Many of the cheap publications of the present day, and unfortunately some of the more costly, are poorly printed as to character of type, paper, space between the lines (*i.e.* "leading"), and "spacing," or distance between the words on the lines, and are therefore injurious to the eyes.

"For all readers, *pearl* type, such as in these eleven words,

"or of this size, *agate*, is altogether too small.

"The same may be said of *nonpareil*, which unfortunately is used in periodical and other reading matter extensively circulated among children and others.

"*Minion* is larger, yet must be considered bad for the eyes, for it is much too small.

"Even the next larger size, *brevier*, is not large enough, although very commonly employed.

"Bourgeois type comes next in the scale, but for prolonged reading, as in encyclopædias and numerous other much-used books, as well as periodicals and newspapers,

"it is inferior to *long primer*, which is a standard size for most well-printed books.

"A still larger size, such as *small pica*, is better for young children.

"For the very young, *pica*, as seen in these two lines, is none too large.

"Great primer type should be employed in the first books that are put before the eyes of the youngest children."

—CURRIER, *Practical Hygiene.*

PAGE **364**, § 392 (*a*). **Sense Education.** — Excellent work has been accomplished by "sense education" in the Seguin Physiological School, New York. The following extract from a newspaper article, referring especially to the education of the voice in the feeble-minded at the above-named school, is so *apropos* that it is appended: "There is that most depressing sight, the mouth of the child of feeble mind and body. Open it stands, gaping wide, with its pendulous lower lip. The facial muscles are ignorant of their duty. It is not will-power alone which will ever bring those lips together. Still this can be and is corrected. The child is taught to close it. Constantly the gentle teacher brings her finger to the child's lips, and an effort is made, after a while, by a self-sustained will, to close it. Sometimes a straw is held in the mouth, to show the child how to grasp it with the lips. After a while, when his attention is occupied with something else, he forgets to close it. The act of having his mouth open is noticed, and he shuts it at a word of command. He may have been perfectly unable a few months ago to arrest a flow of saliva from his mouth; but now this secretion, which was over-abundant, has ceased. He might have been once a saddening sight to see; but now much of that idiotic blankness has gone. But is it simply the child's appearance which has been improved? No. A thousand things may

arise from this simple mouth instruction which are of advantage to the child in the sense of a brain-awakening. His speech has been thick and unintelligible. How could the poor lad pronounce a word properly, hampered as he was with rigid lips? Now he is taught to pronounce letters properly. Every sound of every letter may have to be taught him. The lips become pliant, vibrate at last, and from what was a dumb, inanimate, resoundless block, distinct musical words now are flowing. The visitor is deeply impressed with what he has witnessed. He has seen the effect of constant, assiduous, philosophical training. He looks at a series of portraits of the children, and marks how rapid have been the changes. It is this sense-education which has taken from these drear faces their animal look, and made them human once more. Dr. Seguin it is who, though he be dead now, has given new life to many of God's creatures, and it is his wife who has carried out his work."

PAGE **374**, § 402 (*a*). **Rules for the Care of the Voice.**—"No man who is conscious of the ability to speak effectively can undervalue the power of a pleasant voice; and no hearer of a melodious voice but will acknowledge its influence. We have, probably, all been charmed, and our attention riveted, by such a voice, even when the discourse was not above commonplace. The converse of this is, alas! more often met with. It is a fact that many of the greatest thinkers, scholars, and writers use in public speaking and reading a heavy, low monotone, or they rasp the ear with a high and strident pitch. Their 'thoughts that breathe, and words that burn,' fall lifeless and cold, nay, even weary and repel their listeners, who experience a sense of relief when the inharmonious voice ceases; the speaker also being thankful that his painful struggle to be heard is over. How much the influence of the unfortunate possessor of such a voice is nullified! If a statesman, how small must be his success in directing the fortunes of a nation! If a clergyman, painfully will he feel that his earnest endeavors avail him nothing. If a barrister, he sees judge and jurymen sleeping, and to the detriment of his client he may lose his carefully prepared case. Yet, in almost every instance, a voice which has no inherent beauty may, by correct training, become attractive and pleasant, and obtain clearness, smoothness, and commanding resonance.

"*Rules.* 1. Never endeavor to produce a vocal tone without having plenty of breath, and that thoroughly under control. 2. Hold the breath when *in*spired, and commence to *ex*pire only on commencing to speak or sing, that is, at the moment it is required to set the ligaments in vibration. 3. Do not think that loudness is essential to force or beauty;

shouting is always injurious. The telling quality of *laryngeal* tone depends solely on the amplitude of the vibrations, and this is controlled solely and entirely by the *will*, which directs the due proportion of air to set the vocal ligaments into more or less full vibration. For all purposes of practice it is especially advisable for the pupil to sing *piano*, which term does not imply diminished vigor, but simply reduced amplitude of the vibrations. 4. Never use the voice when functional failure gives warning that the organ, or the general health, is disordered. 5. Do not attempt to use the voice in unfavorable circumstances, as in the open air, especially if the weather be cold or raw, nor in a room impregnated with tobacco smoke, foul air, or dust. Above all, do not use the voice, even for conversation, in trains or vehicles, or in any circumstances of noise which will require undue functional exertion. In this connection it will be important to keep quiet, and avoid chattering and laughing, between songs or the acts of a drama or opera. 6. Do not use the voice for too long a period at a time, but always cease before fatigue is experienced. Especially avoid *encores* of songs which have required much exertion, or production of a telling high note in the final *cadenza*. It is but rarely that a song is sung as well on a redemand as at first. 7. After continued singing or speaking, be careful to prevent exposure of the throat, either externally or internally, to the impressions of cold air. The same remark applies as to the necessity of guarding against sudden changes from hot to cold air, even when the voice has not been used."—Browne, *Voice, Song, and Speech.*

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